General Loss Estimation for Natural Hazards

GENERAL METHODOLOGY

For this 2014 update, the general loss estimation tables for Michigan counties for flooding, tornadoes, thunderstorm hazards, winter storms, subsidence, coastal erosion, and earthquakes were predominantly developed using data from the National Climatic Data Center. The fact that NCDC is based on actual damaging events rather than theoretical estimates was a primary reason to shift to using this source, as well as its relative ease of use and authoritative source. Previous MHMP editions had attempted to begin with census data describing all households, and then estimate average damage amounts from derived area/frequency information across Michigan. This was considered to be a less valid method than making use of nearly 20 years of event data, now available in NCDC for many natural hazards. Updated census data regarding each county's population was used, however, to provide an additional reminder that life safety is a primary concern, even though this Attachment is meant to meet one of the planning requirements by estimating losses, in terms of quantitative damages. Information on life safety information can be found in the NCDC-derived summary tables in the hazard analysis sections of this plan. The newest census information from 2010 was used, along with NCDC searches from early 2014, which provided data on events as recent as October, 2013.

The primary data source for hazard occurrences and hazard related damages was the National Climatic Data Center (NCDC) Storm Data for Michigan. The NCDC Storm Data provided frequency and damage data for the following hazards: tornadoes, several kinds of strong and severe winds (which were combined together for this analysis), hail, lightning, snowstorms, ice/sleet storms, flooding, and wildfires. Although the type of information included in this data source has changed over the years (and tends to now include a lot of routine, non-emergency situations such as precipitation), this change seems to have resulted in a more consistent and thorough tally of annual events. These data were totaled for each county, similar hazards were summed together, and the total number of events was divided by the total time period to provide estimates of the historical probability of each hazard event per year, as well as the average/expected levels of damage from each hazard per year. These recent historical statistics were considered to be an appropriate means of estimating the future probability of hazard occurrences, however, this Attachment provides an extra type of analysis beyond that presented in the main hazard analysis sections, as will shortly be explained. For flooding, instead of focusing upon the reported number of flood prone residential units in each county as per the National Flood Insurance Program (NFIP) Community Information System (CIS) database, instead used the same procedure as the other hazards, for the current 2014 update.

A new feature in this update is the use of "smoothed data" for all of the above listed hazards except for flooding. All these natural hazards, except for flooding due to its tendency to predominantly affect low-lying areas of floodplains and specific weak-spots in urban drainage systems, have a wide-ranging potential area of impact. The fact that the historical data, although fairly extensive, dates back no more than 20 years from this source, meant that for less frequent hazards, such as tornadoes, an incorrect impression of the actual risks of damage might be obtained by using only the raw data alone. After all, if one tornado strikes a particular area of the state only once every 20 years in a damaging fashion, the fact that it had most recently occurred in one specific county does not mean that the risks for adjacent counties should be considered negligible. Rather, a means was need to allow the actual impacts to also reflect upon the general area where they could just as easily have struck, rather than just the specific area that they happened by chance to affect most recently. The procedure for adjusting the data, or "smoothing" it across adjacent counties, was to first use the original data as already presented in the tables throughout the hazard analysis sections of this plan, and to replace each county's information with an average of the statistics for itself plus all of its contiguous counties. This was accomplished through the use of Geographic Information Systems, and mapped output has also been provided in this Attachment, for easy statewide comparisons. (Detailed comparisons can make use of the tabular, numeric data.) Two iterations of "smoothing" were performed on seven natural hazards, so that the areas fairly proximate to (i.e. up to two counties away) some previous damaging event would be given non-zero risk and loss estimates.

Although subsidence and high risk erosion event data has been rather limited at all levels of analysis, previous editions of this plan had still considered it valid to attempt somewhat accurate estimates of potential losses to residential structures in identified subsidence and high risk erosion areas. For this updated plan, the lack of overall risk from these hazards, and the lack of a convenient procedure to assess what limited data has been obtained, means that there is little meaningful expansion that can be made upon the information already provided in those sections of the hazard analysis, in the main body of this document. Recent subsidence events data makes clear that the hazard rarely causes much damage, and the knowledge of which regions of the state had been appealing to extraction industries does not narrow or define the risks enough to produce a valid analysis. Although high risk erosion areas may be more calculable with available information, the primary data source currently available was the set of township-level high risk erosion zone maps provided by the MDEQ and described in the Great Lakes Shoreline Hazards section of the Hazards Analysis, in this plan. Yet, the history of actual hazard events shows very limited long-term effects from this hazard. **Most of the natural hazards have already had their county loss estimates provided in the new, two-page tables found in the appropriate hazard analysis sections. Attachment A supplements these tables where additional analysis was felt to be possible and valid.**

SMOOTHED DATA

Due to the fairly short timeframe of historical records from the NCDC data for Michigan (January 1996 – October 2013), some counties that have known risks from tornadoes, severe wind, hail, lightning, snowstorms, ice/sleet events, and wildfires technically did not have recorded events or damages. To avoid giving the impression of zero risk in these counties, the data was smoothed (twice) in an attempt to represent a more realistic picture of expected risk. This was accomplished by averaging estimated losses across each county and its contiguous neighbors, in order to distribute individual county losses more validly across a regional area. The data was smoothed by totaling the expected annual losses in a county with those from its adjacent counties, dividing by the total number of counties to find an average, and then assigning that average value to the central county in a new list (an "iteration"). After this process was applied once for the entire state, the calculations were then performed a second time (a "second iteration") using the averaged values from the first run. In the loss estimation tables that follow in this section for tornadoes, severe wind, hail, lightning, snowstorms, ice/sleet events, and wildfires, the smoothed data results (after two iterations) appear in the far right hand column for each county. Additionally, the maps that follow each table represent the estimated annual risk for that hazard based on the smoothed data. Geographic Information Systems were used by MSP specialists, for this process.

RELATIVE RISK

The "Relative Risk" column displays risk categories that have been derived for Michigan's natural hazards which have been able to be analyzed in terms of their property impacts. (Hazards such as extreme temperatures, which predominantly affect people, are described later.) The categories are based upon the estimated annual expected damages for each county, in a way that makes general comparisons across different hazard types. The Relative Risk is based on the expected annual losses from the smoothed data (except for flooding, which did not use a smoothing process). The relative risk categories are therefore based upon the amounts that were calculated in this risk analysis and displayed in the tables for each hazard. These categories are the following ones:

HIGH RISK – the expected annual losses are $200,000 or more.

MEDIUM RISK – the expected annual losses are between $5,000 and $199,999.

LOW RISK – the expected annual losses are less than $5,000.

Methods for Broadly Analyzing the Impacts of Natural Hazards upon Michigan Counties

FLOODING

Loss estimates for flooding were tabulated using data from the NCDC. The total number of flood events reported from January 1996 through October 2013 was divided by the number of years in the reporting period (17.83), to establish the annual number of flood events that each county has had (called "Expected Annual Events"). Then, the total dollar amount of property damage (including crop damages) was divided by the total number of events to calculate the average damage per event for each county. The per event damage amount was then multiplied by the number of expected annual events to produce the "Expected Annual Losses" amount for each county. No adjustments were made for inflation in the data for damage amounts, and Michigan total amounts were obtained separately from the NCDC source, and calculated separately, because NCDC often includes multi-county events that involved a risk of being double-counted and thus inflating the actual damages if they had been totaled within these tables. No "smoothing" process was applied to the flood hazards, because flooding generally affects specific at-risk locations, rather than randomly striking just anywhere (or everywhere) in the state, as so many of Michigan's weather hazards can.

For an example of how flood losses were estimated, consider the data for Allegan County, which had 34 such events over a 17.83 year period. This averages about 1.91 events per year, and the average amount of damage per event was $837,500 (calculated by dividing the total damages of $28,475,000 by 34 events). So the estimated damages per year comes out to ~1.91 x $837,500 = $1,597,027.

SPECIAL NOTE: The 2014 edition of the MHMP used newly collected sets of data. In addition to new U.S. Census information, a revamped online database of the National Climatic Data Center was consulted. Rather than re-use the method of flood analysis that had been present in the 2011 edition, which used CIS survey data and census information to assess the number of residential units in the flood plan, this plan uses NCDC data about actual past damages in each county to estimate the overall impacts of the flood hazard. The decennial U.S. census is of population and housing, and thus contains no information about the many types of non-residential structures located in Michigan's communities (and floodplains). The use of NCDC data therefore allows a full range of flood impacts to be included in the estimates of flood risk, based upon actual past events.

In the case of state facilities, the newest available list of facilities was compared with the location of floodplains, to produce a small list of facilities that have flood risks due to their location in or near known floodplain areas. Those facilities had their losses estimated in two ways—one by using a 1% annual chance of flooding, multiplied by a standard flood damage estimation table (originally derived from FEMA 386-2, page 4-13, since the values of these properties were known or calculated (in the confidential section of this Attachment). The other method was to apply the estimated expected flood damage amounts calculated on a county-by-county basis, as had been done for all the other significant natural hazards for which state facility loss estimates were calculated.

TORNADOES

All of Michigan's counties were considered to be at-risk from tornado damages. The risks for each county were calculated from historic data provided by the NCDC in a manner similar (at first) to the technique used to analyze annual flood risks. The total number of tornadoes reported from January 1996 through October 2013 was divided by the number of years in the reporting period (17.83), to establish the annual number of tornadoes that each county has had (called "Expected Annual Events"). Then, the total dollar amount of property damage (including crop damages) was divided by the total number of events to calculate the average damage per event for each county. The per event damage amount was then multiplied by the number of expected annual events to produce the "Expected Annual Losses" amount for each county. No adjustments were made for inflation in the data for damage amounts, but a data smoothing process (see page 640) was then used so that the results of the 17.83-year event history would better generalize to the longer-term, by having tornado damages in nearby counties included in an averaging process that adjusted the raw tornado damage values through two iterations, so that places up to two counties away from a damaging tornado would not have their risks presented as "zero" due merely to the limited historical period under consideration. In the summary table on page 68 in the main body of this plan, adjustments were made to the casualty reports, so that the large-scale human impacts of Michigan's most serious tornado events (1953 and 1965) would be included in the analysis, rather than risk underestimating the potential for the worst tornadoes to again cause such harm (as had been seen in Joplin, MO so recently).

For an example of how tornado losses were estimated, consider the data for Allegan County, which had 7 tornadoes over a 17.83 year period. This averages about 0.39 events per year, and the average amount of damage per event was $228,857 (calculated by dividing the total damages of $1,602,000 by 7 events). So the estimated damages per year comes out to ~0.39 x $228,857 = $89,849. After the tornado impacts of nearby counties were included in the assessment of risks, through two iterations of the smoothing process, Allegan County's risks were estimated to be a bit higher, at $125,334. A place such as Alger County, which would have been assessed as $0 in damages if only the original raw data had been used, instead was estimated as having $12,407 in expected annual tornado losses—considered far more accurate than a figure that implied zero risk. Not all counties had their estimated risks increased by this smoothing process. For example, Cass County had its estimated annual damages decrease as a result of the smoothing process, as it might appear that it had an unusual amount of tornado damage in the period covered by NCDC, purely by chance. However, the tables show both figures, side by side, so that readers, analysts, and local planners and emergency managers may choose whichever they decide to best represent their local risks (or some value between the two presented here).

SEVERE WINDS, HAIL, LIGHTNING, SNOWSTORMS, ICE/SLEET STORMS, AND WILDFIRES

These additional six natural hazards shared with tornadoes the characteristic of potentially being able to affect any county in Michigan (although with different probabilities of doing so). Therefore, their data were assessed in the same manner as that for tornadoes (described above), including a smoothing process. However, since no gargantuan events for these hazards have occurred that compare with the high-casualty F5 tornado events (not otherwise included in the NCDC event history period), no adjustment was made in the summary table on page 68—the estimates were instead carried forward from the calculations based on NCDC sources.

EXTREME TEMPERATURES

Although extreme temperatures had already been assessed in terms of their impacts upon human life, and their limited impacts upon property, in the hazard analysis subsection dedicated to them, some additional analysis has been included in this Attachment, where more space could be used without severely interrupting the flow of the main text's

narrative analysis. Tables are provided here to give the average number of days with temperatures below 0ºF and temperatures above 90ºF, using a 30-year Michigan data set from the Midwestern Regional Climatic Center. Based on the number of days of the extreme temperatures, the proportion of those days in a year annually was calculated by dividing each county's number into 365.4 (days per year). For instance, an average of 55.1 days of extreme cold temperatures for Iron County = 15.1% of the year (the county will continue to annually experience this many days of extreme cold temperatures). Further, a "Relative Risk" category of high, medium or low was determined based on the number of days of the extreme cold and hot temperatures for each county. An equal interval of approximately 28 counties was used to separate the three risk categories amongst the 83 counties. For extreme hot temperatures, LOW RISK = those counties experiencing 0 – 5 days of temperatures above 90°F; MEDIUM RISK = 5.1 – 9 days of temperatures above 90°F; and HIGH RISK = 9.1 or more days of temperatures above 90°F. For extreme cold temperatures, LOW RISK = those counties experiencing 0 – 9.9 days below 0°F; MEDIUM RISK = 10 – 18.9 days below 0°F; and HIGH RISK = 19 or more days below 0°F. These risk categories, unlike all those used for the hazards described above, are not based upon physical damages and therefore are not directly comparable with the other hazards.

SUBSIDENCE, SHORELINE HAZARDS, AND EARTHQUAKES

These three types of hazards were assessed in their individual chapters of the hazard analysis section in the main body of this plan. These are hazards whose history demonstrates that they have very limited physical impacts in Michigan, and it was felt that they had already been sufficiently well-addressed within their individual chapters, and the summary table on page 68. No further elaboration was considered necessary in this section—these hazards generally had no Michigan history in the NCDC source used in this risk assessment, or the event history (such as that for shoreline hazards) showed a preponderance of human impacts rather than physical property impacts. The need for this Attachment stems from the space requirements and detail needed to further analyze hazards that have a much more extensive history of causing physical damages, so it was felt that these hazards had already been well-covered in their hazard analysis chapters, and needed no further elaboration here.

GENERAL FINDINGS

General findings for the entire state have already been summarized in the table on page 68. This Attachment provides a more detailed breakdown of risks by county (as well as an assessment of the impacts upon state owned/operated facilities). In this Attachment, the main content for each county that adds to and differs from the summary tables in the hazard analysis section of this plan tends to stem from the smoothed data operations. These are clearly visible in the rightmost columns of the tables that follow. First, a brief summary of the overall Michigan risks will be worth presenting here (as shown in the Hazard Analysis Summary Table on page 68 of this plan).

To the best that current records could determine, the most frequent natural hazard in Michigan is the severe winds hazard, which averages more than 400 annual occurrences within state territory. However, as with so many hazards, most of the damage from these winds tends to come from the most severe and widespread events, rather than the hundreds that are regularly reported but result in minimal damage. When property and crop damage is considered, Michigan's natural hazards have the following ranking:

- The statewide expected annual loss due to flooding is $25,689,961.*
- The statewide expected annual loss due to severe wind damage is $25,398,151.
- The statewide expected annual loss due to tornado damage is $19,565,003.
- The statewide expected annual loss due to hail damage is $16,587,342.
- The statewide expected annual loss due to ice/sleet storm damage is $11,002,075.
- The statewide expected annual loss due to drought impacts is about $ 8,400,000.
- The statewide expected annual loss due to snowstorm damage is $ 2,288,194.*
- The statewide expected annual loss due to wildfires is $ 1,147,280.
- The statewide expected annual loss due to invasive species is probably $ 1,000,000 or more.
- The statewide expected annual loss due to geomagnetic storm effects is about $ 1,000,000 or less.
- The statewide expected annual loss due to lightning damage is $ 966,310.
- The statewide expected annual loss due to extreme cold damage is about $ 300,000.
- The statewide expected annual loss due to subsidence is about $200,000 (but recent events have involved technological, urban infrastructure breakdowns as a cause, such as broken water mains that cause road collapses, rather than subsidence within old mining areas or the hydrological causes that had been focused upon in previous editions of this plan—subsidence damages from purely natural causes are estimated to average less than $100,000 per year).
- The statewide expected annual loss from earthquakes, shoreline hazards, impacting celestial objects, and earthquakes are each estimated to be less than $100,000.

- Hazards such as extreme heat, fog, and pandemics do not have direct property damage normally associated with them. No clear method was readily available to attempt to estimate the costs of any corollary economic impacts from these hazards.

*** It must be noted that, in this new analysis and comparison of all hazards in Michigan, the most damaging hazard appear to be two types of technological hazards: fixed site hazardous materials incidents (including industrial accidents), and oil/gas pipeline accidents. Each of these was estimated to cause the same annual amount of damage—about $57 million, more than twice the amount of the top natural hazard in the list above—and each of which had, during the past 20 years, included a huge event whose costs topped $1 billion. The third most significant technological hazard was determined to be hazardous materials transportation accidents, which averaged an estimated $3 million or more per year in their impacts. Other technological hazards whose costs could not be well estimated, but which seemed to result in damages of more than $1 million per year, include infrastructure failures, major structural fires, and major transportation accidents.**

The figure for floods does not include the large amount of flood damages that are not reflected in the major events reported by NCDC. As described in the hazard analysis section of this plan, a more comprehensive estimate might result in a figure on the order of $60 million or more, but to verify this estimate in a systematic way will require new comprehensive data sources and a different method of analyzing that data than could currently be performed. Moreover, this would likely include minor events that affect only isolated households, rather than events with the capacity to cause emergency or disaster events for a community. (See the following paragraph for more explanation.)

Flood figures reported by NCDC seem to include dam failures. It is estimated that dam failures, if considered separately from all other flood causes, result in average annual damages of only about $300,000. The results of extreme cold appear comparable, based upon known large scale impacts involving frozen water mains, etc., but if individual household impacts are considered, then the damages from extreme cold would be much higher. However, as is problematic when considering structural fires or transportation accidents, events that occur predominantly on the level of an individual household are not the events that would normally be considered to have the community-wide impact that is the normal concern of emergency management (as distinct from the first responder professions such as firefighters, police, and emergency medical service providers). This plan has focused upon hazards that go beyond single households and individuals (e.g. this plan does not analyze small-scale personal crimes or routine "fender bender" car accidents, even though these add up to substantial monetary losses and personal injury), to hazards that have the real capacity to overwhelm local community response capabilities, or to otherwise cause impacts large enough to result in at least local emergency declaration. Michigan government does encourage preventive activities and hazard mitigation for these small-scale events, but in many cases, the most cost-effective form of hazard mitigation and prevention stems from public awareness, private activities, insurance-related adjustments, etc.; not necessarily community-wide or government-driven action.

Fog has not been known to cause any direct property damage. Other hazards, such as invasive species and drought, do not tend to affect specific properties in a way that lends itself to jurisdictional distinctions (although a regional breakdown has been provided in the drought chapter of the hazard analysis in the main body of this plan). The direct effects of celestial impacts are not expected to vary significantly between Michigan's counties, and the measurement of large-scale satellite, communication, and infrastructure impacts tends to make jurisdictional distinctions inappropriate. There have been too few damaging dam failure events in Michigan to allow a precise jurisdictional loss estimate, but the collected hazard history suggests that most dams present little risk of failure. Various dams have been officially mapped, although there are many whose "hydraulic shadow" has not been plotted (and that would be the minimal information required to allow an even-handed jurisdictional comparison of risk). Somewhat better information has now been used for the much more frequent wildfire hazard; previous plans had mostly used in information pertaining to MDNR state-owned lands rather than privately owned properties with structures, but NCDC has provided enough statewide quantitative information to allow this hazard to finally start to be properly assessed using loss estimates.

Due to the still-tentative nature of many of these loss estimation procedures, it is recommended that readers consider them to be a supplement to (rather than a replacement for) the hazard analysis section of this plan.

In terms of human casualties, the most serious hazard is expected to be public health emergencies, especially pandemics. Following behind that would be extreme heat, tornadoes, severe winds, and cold. These figures are presented in the summary table on page 68 of this plan—a table that has been markedly improved since it first appeared in the previous edition of this plan.

When it comes to the comparative vulnerability of Michigan's Counties, the following table presents a ranking of counties by each of the hazards that was able to be quantitatively assessed in detail here. (However, the table only shows counties that had an estimated expected annual damage amount of at least $1 million from that corresponding hazard.)

County Ranking	Flood Risks	Tornado Risks	Severe Wind Risks	Hail Risks	Ice/Sleet Storm Risks
1	Macomb	Wayne	Ottawa	Van Buren	Macomb
2	Ottawa	Monroe	Muskegon	Berrien	Oakland
3	Allegan	Washtenaw	Kent	Cass	Wayne
4	Kalamazoo	Macomb	Wayne	Kalamazoo	St. Clair
5	Wayne	Oakland	Allegan	Shiawassee	
6	Gogebic	Lenawee		Branch	
7	Ingham			Allegan	

No Michigan Counties had annual expected losses of more than $1 million from lightning, snowstorms, wildfires, extreme temperatures, fog, shoreline hazards, dam failures, drought, earthquakes, subsidence, or celestial impacts. **Please note that technological hazards have not been considered in these comparisons.**

When comparing individual county risks (from natural hazards only) against each other, the following rankings result:

1. Macomb Flooding $5,702,748
2. Ottawa Flooding $3,153,674
3. Wayne Tornadoes $1,772,968
4. Ottawa Severe Winds $1,765,853
5. Monroe Tornadoes $1,713,165
6. Allegan Flooding $1,597,027
7. Washtenaw Hail $1,594,716
8. Berrien Hail $1,573,923
9. Cass Hail $1,542,861
10. Kalamazoo Hail $1,533,810
11. Shiawassee Hail $1,532,297
12. Macomb Ice/Sleet Storms $1,507,568
13. Muskegon Severe Winds $1,423,861
14. Kalamazoo Flooding $1,361,750
15. Washtenaw Tornadoes $1,356,121
16. Kent Severe Winds $1,344,902
17. Oakland Ice/Sleet Storms $1,336,891
18. Wayne Ice/Sleet Storms $1,290,511
19. Wayne Flooding $1,259,675
20. Macomb Tornadoes $1,213,402
21. Wayne Severe Winds $1,182,425
22. Oakland Tornadoes $1,139,969
23. Allegan Severe Winds $1,102,763
24. Branch Hail $1,102,756
25. St. Clair Ice/Sleet Storms $1,092,605
26. Allegan Hail $1,082,724
27. Lenawee Tornadoes $1,070,348
28. Gogebic Flooding $1,066,237
29. Ingham Flooding $1,003,646

Although these rankings may appear to be clear-cut, keep in mind that they do not include a consideration of human casualties, local resources (for example, although more snow falls in the Upper Peninsula, it causes less damage there), and other considerations beyond property damage reports. They are also based upon less than 20 years of data. It will be appropriate for these statistics to be reviewed by multiple agencies, including the involved local emergency management programs, before they are considered appropriate for use in prioritizing state assistance in hazard mitigation activities. (In addition, certain types of hazards are more susceptible to available mitigation options, and therefore any prioritization from this plan cannot be based exclusively upon the extent of perceived property risk.)

Loss Estimation Tables for Counties (and general critical infrastructure vulnerability)

1. Michigan Counties – Flooding
2. Michigan Counties – Tornadoes
3. Michigan Counties – Severe Winds
4. Michigan Counties – Hail
5. Michigan Counties – Lightning
6. Michigan Counties – Snowstorms
7. Michigan Counties – Ice/Sleet Storms
8. Michigan Counties – Wildfires
9. Michigan Counties – Extreme Cold Temperatures (Risk / probability)
10. Michigan Counties – Extreme Hot Temperatures (Risk / probability)
11. General Natural Hazard Vulnerability: Lifelines (utility and transportation infrastructure)

Loss Estimation for the State of Michigan: Flooding

COUNTY	Population*	Relative Risk	Number of Riverine Flood Events: 1996-2013 (NCDC)	Expected Annual Events	NCDC Total Historic Riverine Flood Damage ($millions)	Expected Annual Losses ($)
Alcona	10,942	MEDIUM	4	0.22	0.11	6,169
Alger	9,601	LOW	6	0.34	0.00	0
Allegan	111,408	HIGH	34	1.91	28.48	1,597,027
Alpena	29,598	LOW	1	0.06	0.00	0
Antrim	23,580	LOW	1	0.06	0.00	0
Arenac	15,899	MEDIUM	13	0.73	0.10	5,496
Baraga	8,860	MEDIUM	14	0.79	2.04	114,638
Barry	59,173	HIGH	29	1.63	13.97	783,511
Bay	107,771	HIGH	24	1.35	9.05	507,291
Benzie	17,525	LOW	1	0.06	0.00	0
Berrien	156,813	HIGH	20	1.12	6.91	387,549
Branch	45,248	HIGH	14	0.79	6.16	345,485
Calhoun	136,146	HIGH	27	1.51	13.13	736,399
Cass	52,293	HIGH	21	1.18	6.66	373,528
Charlevoix	25,949	LOW	1	0.06	0.00	112
Cheboygan	26,152	LOW	3	0.17	0.03	1,570
Chippewa	38,520	MEDIUM	6	0.34	0.13	7,011
Clare	30,926	HIGH	8	0.45	4.45	249,579
Clinton	75,382	HIGH	26	1.46	12.87	721,817
Crawford	14,074	LOW	1	0.06	0.01	337
Delta	37,069	MEDIUM	22	1.23	0.81	45,149
Dickinson	26,168	LOW	11	0.62	0.03	1,739
Eaton	107,759	HIGH	25	1.40	12.77	716,209
Emmet	32,694	LOW	1	0.06	0.02	1,010
Genesee	425,790	HIGH	38	2.13	13.91	780,146
Gladwin	25,692	MEDIUM	7	0.39	0.10	5,777
Gogebic	16,427	HIGH	13	0.73	19.01	1,066,237
Gd Traverse	86,986	MEDIUM	6	0.34	1.81	101,739
Gratiot	42,476	HIGH	26	1.46	10.82	606,842
Hillsdale	46,688	HIGH	20	1.12	6.31	353,898
Houghton	36,628	MEDIUM	17	0.95	2.90	162,647
Huron	33,118	HIGH	23	1.29	6.32	354,403

Loss Estimation for the State of Michigan: Flooding – cont.

COUNTY	Population*	Relative Risk	Number of Riverine Flood Events: 1996-2013 (NCDC)	Expected Annual Events	NCDC Total Historic Riverine Flood Damage ($millions)	Expected Annual Losses ($)
Ingham	280,895	HIGH	26	1.46	17.90	1,003,646
Ionia	63,905	HIGH	21	1.18	14.57	817,162
Iosco	25,887	LOW	3	0.17	0.00	168
Iron	11,817	MEDIUM	10	0.56	0.65	36,175
Isabella	70,311	HIGH	27	1.51	14.83	831,464
Jackson	160,248	HIGH	25	1.40	11.43	640,774
Kalamazoo	250,331	HIGH	27	1.51	24.28	1,361,750
Kalkaska	17,153	LOW	2	0.11	0.02	1,122
Kent	602,622	HIGH	38	2.13	11.14	624,790
Keweenaw	2,156	MEDIUM	7	0.39	0.13	7,403
Lake	11,539	HIGH	8	0.45	6.89	386,427
Lapeer	88,319	HIGH	28	1.57	16.78	941,110
Leelanau	21,708	LOW	2	0.11	0.05	2,804
Lenawee	99,892	HIGH	36	2.02	6.81	381,941
Livingston	180,967	MEDIUM	17	0.95	1.30	73,135
Luce	6,631	LOW	3	0.17	0.00	0
Mackinac	11,113	LOW	5	0.28	0.06	3,253
Macomb	840,978	HIGH	34	1.91	101.68	5,702,748
Manistee	24,733	MEDIUM	8	0.45	1.52	85,250
Marquette	67,077	HIGH	27	1.51	14.73	825,855
Mason	28,705	HIGH	13	0.73	8.21	460,179
Mecosta	42,798	HIGH	27	1.51	16.56	928,772
Menominee	24,029	MEDIUM	5	0.28	0.85	47,672
Midland	83,629	HIGH	25	1.40	8.83	495,233
Missaukee	14,849	MEDIUM	3	0.17	0.16	8,974
Monroe	152,021	HIGH	29	1.63	9.89	554,683
Montcalm	63,342	HIGH	24	1.35	10.82	606,842
Montmorency	9,765	LOW	1	0.06	0.00	0
Muskegon	172,188	HIGH	28	1.57	13.49	756,590
Newaygo	48,460	HIGH	10	0.56	6.71	376,332
Oakland	1,202,362	MEDIUM	22	1.23	2.71	151,767

Loss Estimation for the State of Michigan: Flooding – cont.

COUNTY	Population*	Relative Risk	Number of Riverine Flood Events: 1996-2013 (NCDC)	Expected Annual Events	NCDC Total Historic Riverine Flood Damage ($millions)	Expected Annual Losses ($)
Oceana	26,570	HIGH	9	0.50	5.11	286,596
Ogemaw	21,699	MEDIUM	3	0.17	0.15	8,413
Ontonagon	6,780	MEDIUM	12	0.67	0.82	45,822
Osceola	23,528	HIGH	11	0.62	5.83	326,697
Oscoda	8,640	LOW	3	0.17	0.00	168
Otsego	24,164	LOW	1	0.06	0.00	168
Ottawa	263,801	HIGH	34	1.91	56.23	3,153,674
Presque Isle	13,376	LOW		0.00	0.00	0
Roscommon	24,449	LOW	1	0.06	0.00	224
Saginaw	200,169	HIGH	48	2.69	9.84	551,711
St. Clair	163,040	HIGH	24	1.35	9.58	537,297
St. Joseph	61,295	HIGH	18	1.01	6.66	373,528
Sanilac	43,114	HIGH	21	1.18	8.25	462,423
Schoolcraft	8,485	LOW	3	0.17	0.00	0
Shiawassee	70,648	HIGH	27	1.51	7.33	411,161
Tuscola	55,729	HIGH	32	1.79	14.13	792,485
Van Buren	76,258	HIGH	24	1.35	10.90	611,497
Washtenaw	344,791	HIGH	30	1.68	13.05	731,913
Wayne	1,820,584	HIGH	59	3.31	22.46	1,259,675
Wexford	32,735	MEDIUM	10	0.56	0.87	48,906
MI TOTAL	9,883,640		925	51.88	458.05	25,689,961

**Notes: ***2010 Census.

Loss Estimation for the State of Michigan: Tornadoes

COUNTY	Population*	Relative Risk	Number of Tornadoes: 1996-2013 (NCDC)	Expected Annual Events	NCDC Total Historic Tornado Damage ($millions)	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Alcona	10,942	MEDIUM	3	0.17	0.32	17,667	33,006
Alger	9,601	MEDIUM	1	0.06	0.00	0	12,407
Allegan	111,408	MEDIUM	7	0.39	1.60	89,849	125,334
Alpena	29,598	MEDIUM	4	0.22	0.49	27,538	29,157
Antrim	23,580	MEDIUM	2	0.11	0.00	224	14,185
Arenac	15,899	MEDIUM	3	0.17	0.02	897	30,309
Baraga	8,860	MEDIUM		0.00	0.00	0	29,115
Barry	59,173	HIGH	2	0.11	0.30	16,826	293,296
Bay	107,771	MEDIUM	4	0.22	0.17	9,534	101,478
Benzie	17,525	LOW		0.00	0.00	0	4,910
Berrien	156,813	MEDIUM	7	0.39	2.11	118,340	122,728
Branch	45,248	MEDIUM	2	0.11	0.05	2,804	143,545
Calhoun	136,146	HIGH	4	0.22	3.48	194,896	311,684
Cass	52,293	MEDIUM	6	0.34	5.90	330,903	112,945
Charlevoix	25,949	MEDIUM	1	0.06	0.00	0	8,848
Cheboygan	26,152	MEDIUM	2	0.11	0.03	1,683	10,597
Chippewa	38,520	LOW	1	0.06	0.20	11,217	2,854
Clare	30,926	MEDIUM	3	0.17	0.22	12,339	27,461
Clinton	75,382	HIGH	2	0.11	0.60	33,651	425,733
Crawford	14,074	MEDIUM	4	0.22	0.06	3,365	22,242
Delta	37,069	MEDIUM	4	0.22	0.04	2,131	32,180
Dickinson	26,168	MEDIUM	6	0.34	7.13	400,056	79,385
Eaton	107,759	HIGH	8	0.45	50.58	2,836,904	568,341
Emmet	32,694	LOW	1	0.06	0.00	0	1,026
Genesee	425,790	HIGH	18	1.01	18.51	1,038,138	529,851
Gladwin	25,692	MEDIUM	2	0.11	0.09	5,048	32,720
Gogebic	16,427	MEDIUM	1	0.06	0.03	1,402	19,905
Gd Traverse	86,986	MEDIUM		0.00	0.00	0	7,231
Gratiot	42,476	HIGH	5	0.28	0.70	39,484	237,099
Hillsdale	46,688	HIGH	3	0.17	0.35	19,686	410,980
Houghton	36,628	MEDIUM		0.00	0.00	0	11,881
Huron	33,118	MEDIUM	5	0.28	0.42	23,275	106,419

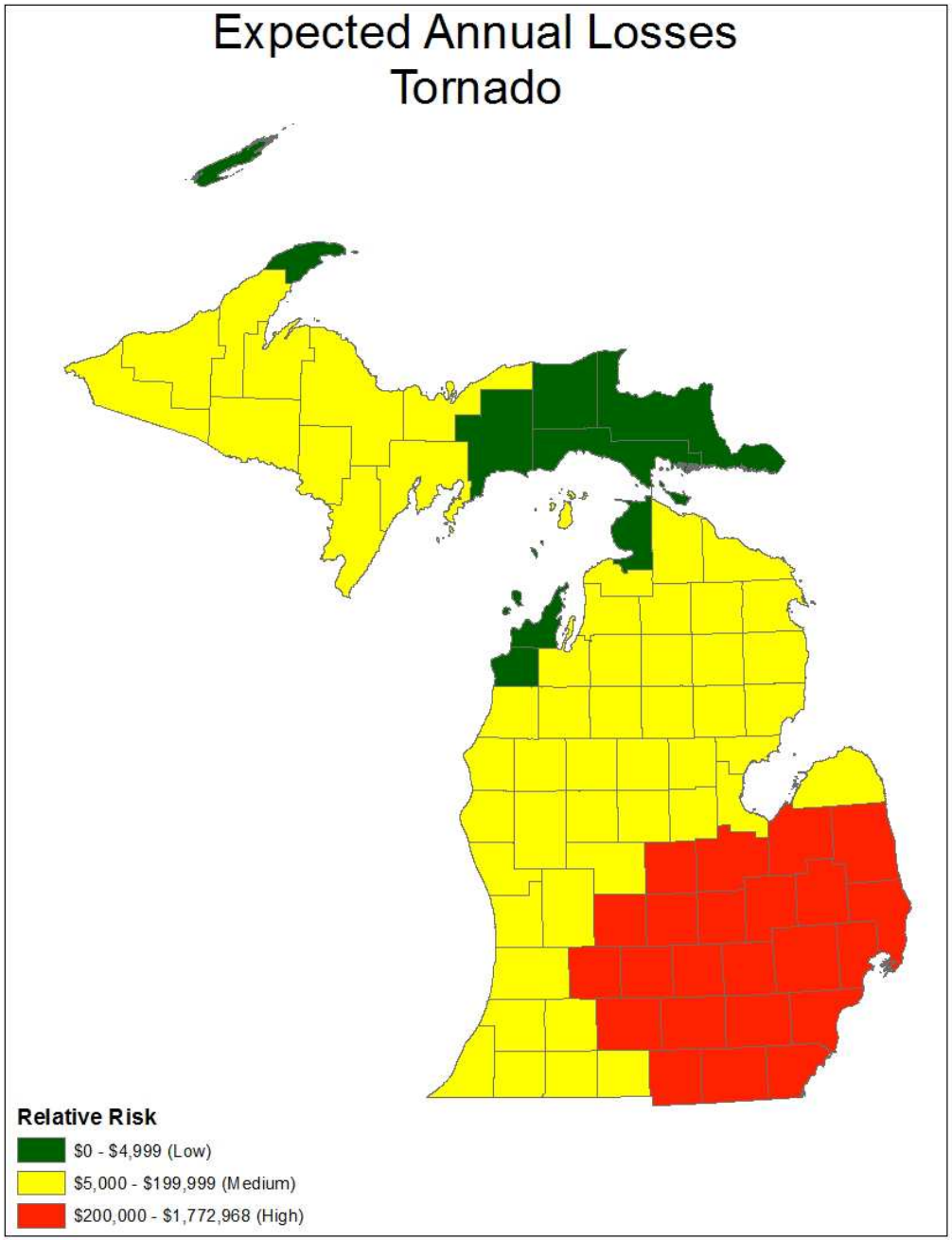
Loss Estimation for the State of Michigan: Tornadoes – cont.

COUNTY	Population*	Relative Risk	Number of Tornadoes: 1996-2013 (NCDC)	Expected Annual Events	NCDC Total Historic Tornado Damage ($millions)	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Ingham	280,895	HIGH	7	0.39	21.05	1,180,595	620,397
Ionia	63,905	HIGH	2	0.11	0.17	9,254	316,417
Iosco	25,887	MEDIUM	1	0.06	0.08	4,206	26,181
Iron	11,817	MEDIUM	1	0.06	0.02	841	31,316
Isabella	70,311	MEDIUM	5	0.28	0.73	40,662	33,922
Jackson	160,248	HIGH	2	0.11	0.75	42,064	677,226
Kalamazoo	250,331	MEDIUM	7	0.39	0.83	46,691	171,424
Kalkaska	17,153	MEDIUM	3	0.17	1.10	61,694	17,911
Kent	602,622	MEDIUM	7	0.39	0.60	33,651	129,786
Keweenaw	2,156	LOW	1	0.06	0.00	0	196
Lake	11,539	MEDIUM	1	0.06	0.20	11,217	12,796
Lapeer	88,319	HIGH	9	0.50	1.88	105,440	636,825
Leelanau	21,708	LOW	1	0.06	0.02	1,122	2,966
Lenawee	99,892	HIGH	4	0.22	0.58	32,529	1,070,348
Livingston	180,967	HIGH	8	0.45	10.22	573,191	816,072
Luce	6,631	LOW	1	0.06	0.00	0	1,917
Mackinac	11,113	LOW	1	0.06	0.00	0	2,200
Macomb	840,978	HIGH	4	0.22	30.80	1,727,426	1,213,402
Manistee	24,733	MEDIUM	1	0.06	0.02	841	7,027
Marquette	67,077	MEDIUM	4	0.22	0.02	841	45,633
Mason	28,705	MEDIUM	1	0.06	0.00	0	8,366
Mecosta	42,798	MEDIUM	1	0.06	1.20	67,302	22,698
Menominee	24,029	MEDIUM	2	0.11	0.03	1,402	65,166
Midland	83,629		3	0.17	0.23	12,619	69,956
Missaukee	14,849	MEDIUM	1	0.06	0.00	0	18,119
Monroe	152,021	MEDIUM	7	0.39	60.20	3,376,500	1,713,165
Montcalm	63,342	HIGH	2	0.11	0.18	9,927	151,124
Montmorency	9,765	MEDIUM	3	0.17	0.21	11,778	25,636
Muskegon	172,188	MEDIUM	3	0.17	0.05	2,804	18,121
Newaygo	48,460	MEDIUM	4	0.22	0.07	4,038	16,678
Oakland	1,202,362	MEDIUM	6	0.34	6.92	387,942	1,139,969

Loss Estimation for the State of Michigan: Tornadoes – cont.

COUNTY	Population*	Relative Risk	Number of Tornadoes: 1996-2013 (NCDC)	Expected Annual Events	NCDC Total Historic Tornado Damage ($millions)	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Oceana	26,570	MEDIUM		0.00	0.00	0	10,152
Ogemaw	21,699	MEDIUM	2	0.11	0.08	4,206	24,971
Ontonagon	6,780	MEDIUM	1	0.06	0.02	1,122	15,027
Osceola	23,528	MEDIUM	5	0.28	0.61	34,324	19,591
Oscoda	8,640	MEDIUM	4	0.22	2.89	162,086	31,824
Otsego	24,164	MEDIUM	1	0.06	0.01	617	16,611
Ottawa	263,801	MEDIUM	3	0.17	0.26	14,582	25,894
Presque Isle	13,376	MEDIUM	2	0.11	0.00	0	21,042
Roscommon	24,449	MEDIUM		0.00	0.00	0	20,390
Saginaw	200,169	HIGH	13	0.73	6.31	354,094	212,944
St. Clair	163,040	HIGH	7	0.39	0.90	50,196	621,653
St. Joseph	61,295	MEDIUM	6	0.34	0.82	46,113	145,920
Sanilac	43,114	HIGH	5	0.28	0.45	24,958	256,211
Schoolcraft	8,485	LOW		0.00	0.00	0	1,344
Shiawassee	70,648	HIGH	9	0.50	0.66	36,736	437,325
Tuscola	55,729	HIGH	8	0.45	1.06	59,450	209,156
Van Buren	76,258	MEDIUM	4	0.22	0.12	6,730	99,908
Washtenaw	344,791	HIGH	5	0.28	12.60	706,394	1,356,121
Wayne	1,820,584	HIGH	3	0.17	90.75	5,089,736	1,772,968
Wexford	32,735	MEDIUM	1	0.06	0.01	449	10,319
MI TOTAL	9,883,640		292	16.38	348.84	19,565,003	

Notes: *2010 Census.


Expected Annual Losses
Tornado
Relative Risk
$0 - $4,999 (Low)
$5,000 - $199,999 (Medium)
$200,000 - $1,772,968 (High)

Loss Estimation for the State of Michigan: Severe Winds

COUNTY	Population*	Relative Risk	Number of Damaging Wind events: 1996-2013 (NCDC)	Expected Annual Events	Adjusted Historic Wind Damage ($) (NCDC)	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Alcona	10,942	MEDIUM	42	2.36	93,000	5,216	11,269
Alger	9,601	MEDIUM	45	2.52	1,252,000	70,219	97,825
Allegan	111,408	HIGH	246	13.80	3,116,000	174,762	1,102,763
Alpena	29,598	MEDIUM	40	2.24	190,000	10,656	10,465
Antrim	23,580	MEDIUM	55	3.08	231,000	12,956	12,520
Arenac	15,899	MEDIUM	28	1.57	222,500	12,479	70,226
Baraga	8,860	MEDIUM	49	2.75	463,500	25,996	65,695
Barry	59,173	HIGH	201	11.27	2,587,000	145,093	823,604
Bay	107,771	MEDIUM	105	5.89	4,986,000	279,641	180,467
Benzie	17,525	MEDIUM	24	1.35	158,000	8,861	23,280
Berrien	156,813	MEDIUM	178	9.98	986,000	55,300	104,169
Branch	45,248	HIGH	162	9.09	422,500	23,696	372,288
Calhoun	136,146	HIGH	156	8.75	29,505,000	1,654,795	474,862
Cass	52,293	MEDIUM	137	7.68	1,223,000	68,592	199,084
Charlevoix	25,949	MEDIUM	35	1.96	273,000	15,311	12,102
Cheboygan	26,152	MEDIUM	30	1.68	181,000	10,151	15,776
Chippewa	38,520	MEDIUM	31	1.74	75,500	4,234	34,559
Clare	30,926	MEDIUM	41	2.30	534,500	29,978	92,506
Clinton	75,382	HIGH	196	10.99	3,177,000	178,183	468,870
Crawford	14,074	MEDIUM	28	1.57	252,000	14,133	12,963
Delta	37,069	MEDIUM	68	3.81	5,236,200	293,674	106,117
Dickinson	26,168	MEDIUM	60	3.37	878,000	49,243	73,247
Eaton	107,759	HIGH	196	10.99	5,465,000	306,506	536,231
Emmet	32,694	MEDIUM	35	1.96	281,000	15,760	12,404
Genesee	425,790	HIGH	384	21.54	9,972,000	559,282	483,400
Gladwin	25,692	MEDIUM	31	1.74	256,500	14,386	92,556
Gogebic	16,427	MEDIUM	83	4.66	1,171,500	65,704	72,778
Gd. Traverse	86,986	MEDIUM	38	2.13	301,500	16,910	19,772
Gratiot	42,476	HIGH	162	9.09	2,523,000	141,503	410,084
Hillsdale	46,688	HIGH	150	8.41	562,500	31,548	390,922
Houghton	36,628	MEDIUM	64	3.59	1,138,500	63,853	59,213
Huron	33,118	HIGH	118	6.62	3,091,000	173,360	236,593

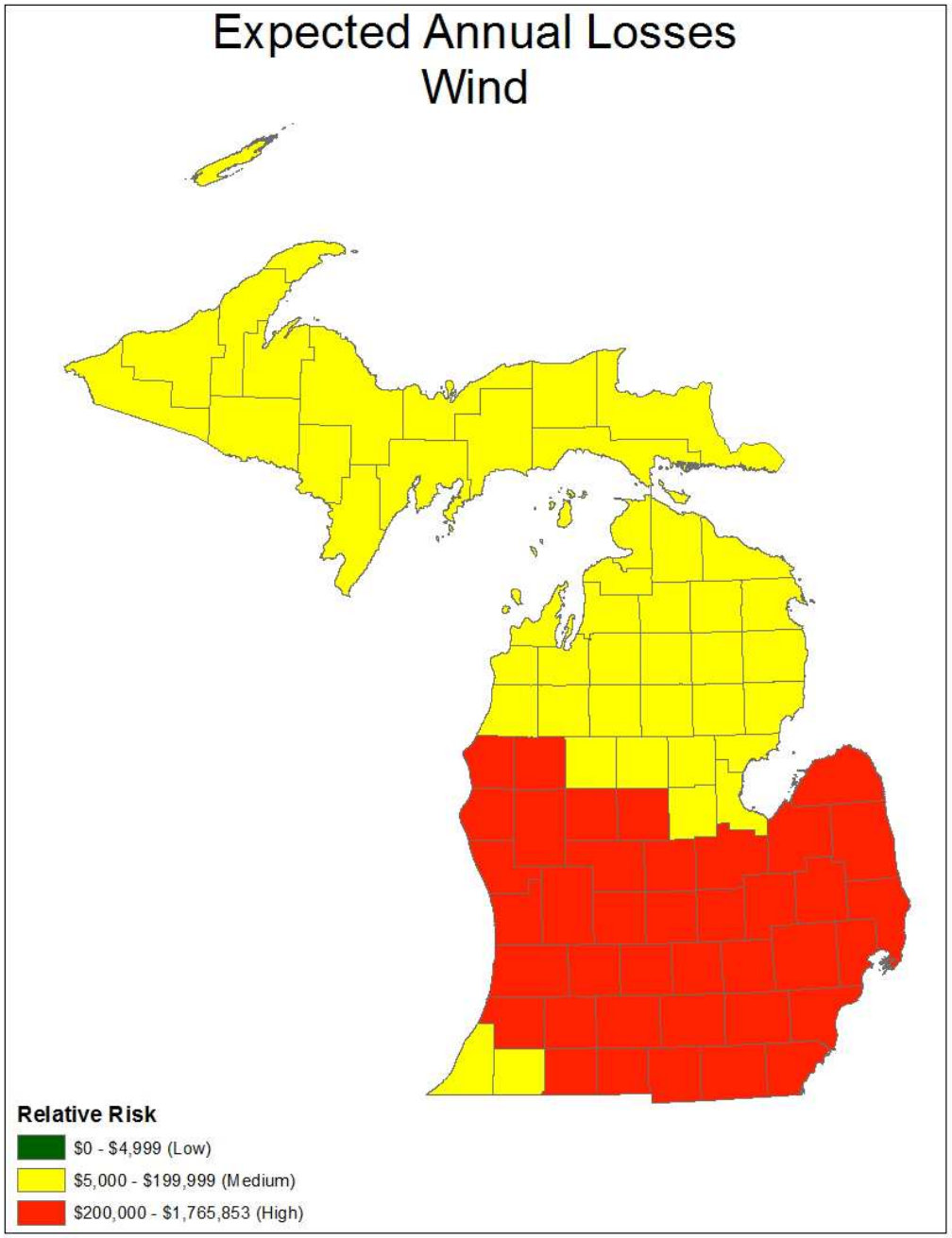
Loss Estimation for the State of Michigan: Severe Winds – cont.

COUNTY	Population*	Relative Risk	Number of Damaging Wind events: 1996-2013 (NCDC)	Expected Annual Events	Adjusted Historic Wind Damage ($) (NCDC)	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Ingham	280,895	HIGH	210	11.78	6,145,000	344,644	363,704
Ionia	63,905	HIGH	184	10.32	2,486,000	139,428	738,863
Iosco	25,887	MEDIUM	36	2.02	151,000	8,469	23,462
Iron	11,817	MEDIUM	55	3.08	2,070,500	116,125	67,590
Isabella	70,311	HIGH	54	3.03	1,280,000	71,789	223,385
Jackson	160,248	HIGH	118	6.62	1,240,000	69,546	438,144
Kalamazoo	250,331	HIGH	124	6.95	5,953,000	333,875	511,684
Kalkaska	17,153	MEDIUM	28	1.57	63,000	3,533	15,684
Kent	602,622	HIGH	227	12.73	83,624,000	4,690,073	1,344,902
Keweenaw	2,156	MEDIUM	38	2.13	341,000	19,125	49,519
Lake	11,539	HIGH	31	1.74	2,144,000	120,247	244,510
Lapeer	88,319	HIGH	277	15.54	5,496,000	308,245	630,256
Leelanau	21,708	MEDIUM	33	1.85	131,000	7,347	13,109
Lenawee	99,892	HIGH	216	12.11	7,254,000	406,842	673,235
Livingston	180,967	HIGH	219	12.28	3,319,500	186,175	547,944
Luce	6,631	MEDIUM	36	2.02	172,000	9,647	66,961
Mackinac	11,113	MEDIUM	24	1.35	89,000	4,992	45,375
Macomb	840,978	HIGH	279	15.65	22,953,000	1,287,325	966,132
Manistee	24,733	MEDIUM	45	2.52	538,500	30,202	53,212
Marquette	67,077	MEDIUM	119	6.67	619,750	34,759	84,246
Mason	28,705	HIGH	48	2.69	1,692,000	94,896	336,081
Mecosta	42,798	HIGH	40	2.24	636,110	35,676	322,431
Menominee	24,029	MEDIUM	64	3.59	124,500	6,983	87,809
Midland	83,629	MEDIUM	88	4.94	2,828,000	158,609	175,648
Missaukee	14,849	MEDIUM	20	1.12	301,000	16,882	25,475
Monroe	152,021	HIGH	198	11.10	5,030,000	282,109	957,589
Montcalm	63,342	HIGH	183	10.26	16,454,000	922,827	622,814
Montmorency	9,765	MEDIUM	38	2.13	240,000	13,460	10,910
Muskegon	172,188	HIGH	191	10.71	34,521,250	1,936,133	1,423,861
Newaygo	48,460	HIGH	51	2.86	2,158,000	121,032	664,271
Oakland	1,202,362	HIGH	414	23.22	16,319,000	915,255	863,500

Loss Estimation for the State of Michigan: Severe Winds – cont.

COUNTY	Population*	Relative Risk	Number of Damaging Wind events: 1996-2013 (NCDC)	Expected Annual Events	Adjusted Historic Wind Damage ($) (NCDC)	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Oceana	26,570	HIGH	38	2.13	4,657,000	261,189	717,050
Ogemaw	21,699	MEDIUM	51	2.86	450,530	25,268	27,750
Ontonagon	6,780	MEDIUM	59	3.31	1,117,000	62,647	68,971
Osceola	23,528	MEDIUM	32	1.79	589,500	33,062	189,604
Oscoda	8,640	MEDIUM	27	1.51	168,000	9,422	11,977
Otsego	24,164	MEDIUM	38	2.13	180,500	10,123	11,774
Ottawa	263,801	HIGH	209	11.72	49,047,000	2,750,813	1,765,853
Presque Isle	13,376	MEDIUM	26	1.46	80,000	4,487	9,664
Roscommon	24,449	MEDIUM	51	2.86	233,000	13,068	25,749
Saginaw	200,169	HIGH	292	16.38	7,935,000	445,036	278,417
St. Clair	163,040	HIGH	286	16.04	6,684,000	374,874	652,701
St. Joseph	61,295	HIGH	145	8.13	648,750	36,385	277,727
Sanilac	43,114	HIGH	92	5.16	2,733,500	153,309	356,225
Schoolcraft	8,485	MEDIUM	35	1.96	3,288,000	184,408	89,305
Shiawassee	70,648	HIGH	230	12.90	5,055,000	283,511	329,396
Tuscola	55,729	HIGH	145	8.13	3,290,950	184,574	305,362
Van Buren	76,258	HIGH	114	6.39	1,551,000	86,988	393,170
Washtenaw	344,791	HIGH	300	16.83	13,335,000	747,897	833,054
Wayne	1,820,584	HIGH	306	17.16	64,495,000	3,617,218	1,182,425
Wexford	32,735	MEDIUM	36	2.02	194,000	10,881	34,790
MI TOTAL	9,883,640		7,324	410.77	452,849,030	25,398,151	

Notes: *2010 Census


Expected Annual Losses
Wind
Relative Risk
$0 - $4,999 (Low)
$5,000 - $199,999 (Medium)
$200,000 - $1,765,853 (High)

Loss Estimation for the State of Michigan: Hail

COUNTY	Population*	Relative Risk	Number of Damaging Hailstorms: 1996-2013 (NCDC)	Expected Annual Events	Historic Hailstorm Damage ($) (NCDC)	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Alcona	10,942	MEDIUM	41	2.30	0	0	11,544
Alger	9,601	HIGH	40	2.24	5,000	280	401,951
Allegan	111,408	HIGH	47	2.64	1,024,000	57,431	1,082,724
Alpena	29,598	MEDIUM	28	1.57	0	0	24,509
Antrim	23,580	LOW	25	1.40	30,000	1,683	531
Arenac	15,899	LOW	31	1.74	0	0	1,238
Baraga	8,860	HIGH	31	1.74	0	0	530,590
Barry	59,173	HIGH	39	2.19	565,000	31,688	818,667
Bay	107,771	MEDIUM	41	2.30	0	0	9,555
Benzie	17,525	LOW	9	0.50	0	0	1,662
Berrien	156,813	HIGH	39	2.19	1,308,000	73,360	1,573,923
Branch	45,248	HIGH	54	3.03	1,000,000	56,085	1,102,756
Calhoun	136,146	HIGH	34	1.91	610,000	34,212	855,720
Cass	52,293	HIGH	23	1.29	12,000	673	1,542,861
Charlevoix	25,949	MEDIUM	26	1.46	0	0	7,013
Cheboygan	26,152	MEDIUM	15	0.84	0	0	16,547
Chippewa	38,520	LOW	22	1.23	0	0	766
Clare	30,926	MEDIUM	29	1.63	565,000	31,688	12,191
Clinton	75,382	MEDIUM	26	1.46	265,000	14,863	99,012
Crawford	14,074	LOW	18	1.01	0	0	4,052
Delta	37,069	HIGH	63	3.53	4,000	224	583,925
Dickinson	26,168	HIGH	54	3.03	225,000	12,619	747,931
Eaton	107,759	HIGH	41	2.30	760,000	42,625	375,589
Emmet	32,694	MEDIUM	15	0.84	100,000	5,609	11,525
Genesee	425,790	MEDIUM	157	8.81	0	0	25,647
Gladwin	25,692	MEDIUM	29	1.63	0	0	6,401
Gogebic	16,427	HIGH	45	2.52	750,000	42,064	239,173
Gd. Traverse	86,986	LOW	18	1.01	0	0	1,723
Gratiot	42,476	MEDIUM	25	1.40	265,000	14,863	79,545
Hillsdale	46,688	HIGH	35	1.96	2,000,000	112,170	524,431
Houghton	36,628	HIGH	43	2.41	10,000	561	327,459
Huron	33,118	LOW	54	3.03	5,000	280	2,617

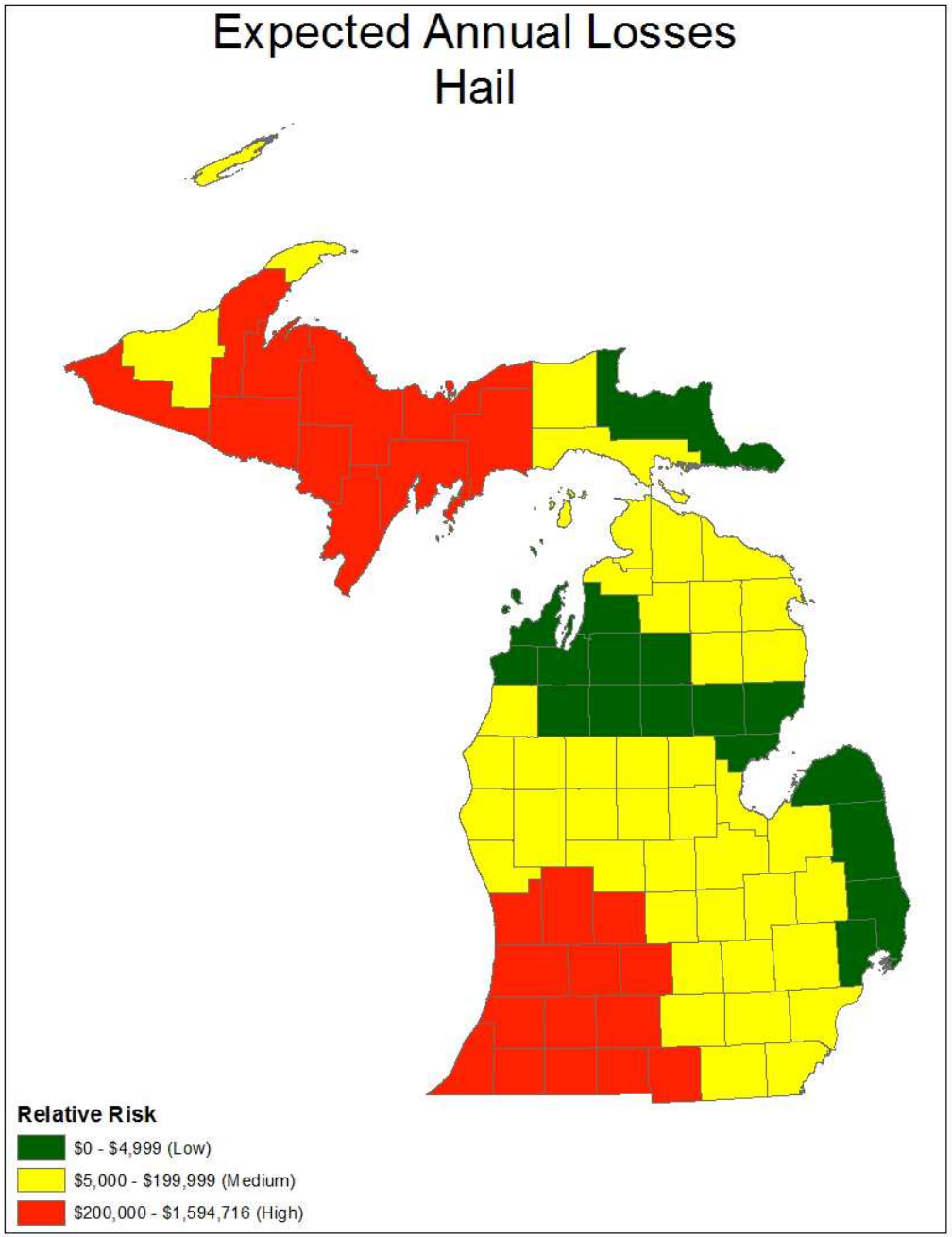
Loss Estimation for the State of Michigan: Hail – cont.

COUNTY	Population *	Relative Risk	Number of Damaging Hailstorms: 1996-2013 (NCDC)	Expected Annual Events	Historic Hailstorm Damage ($) (NCDC)	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Ingham	280,895	MEDIUM	40	2.24	635,000	35,614	61,677
Ionia	63,905	HIGH	14	0.79	4,275,000	239,764	281,789
Iosco	25,887	LOW	47	2.64	0	0	0
Iron	11,817	HIGH	42	2.36	4,100,000	229,950	464,236
Isabella	70,311	MEDIUM	33	1.85	315,000	17,667	40,688
Jackson	160,248	MEDIUM	37	2.08	605,000	33,932	165,200
Kalamazoo	250,331	HIGH	54	3.03	130,050,000	7,293,887	1,533,810
Kalkaska	17,153	LOW	9	0.50	0	0	1,645
Kent	602,622	HIGH	74	4.15	15,322,000	859,338	518,948
Keweenaw	2,156	MEDIUM	4	0.22	0	0	23,191
Lake	11,539	MEDIUM	15	0.84	175,000	9,815	25,774
Lapeer	88,319	MEDIUM	59	3.31	0	0	7,373
Leelanau	21,708	LOW	29	1.63	55,000	3,085	960
Lenawee	99,892	MEDIUM	91	5.10	2,150,000	120,583	44,998
Livingston	180,967	MEDIUM	45	2.52	0	0	38,707
Luce	6,631	MEDIUM	15	0.84	0	0	145,979
Mackinac	11,113	MEDIUM	12	0.67	0	0	6,954
Macomb	840,978	LOW	122	6.84	2,000	112	1,745
Manistee	24,733	MEDIUM	19	1.07	35,000	1,963	5,052
Marquette	67,077	HIGH	114	6.39	64,647,000	3,625,743	772,807
Mason	28,705	MEDIUM	16	0.90	105,000	5,889	32,470
Mecosta	42,798	MEDIUM	22	1.23	475,000	26,640	51,549
Menominee	24,029	HIGH	54	3.03	100,000	5,609	790,128
Midland	83,629	MEDIUM	72	4.04	1,000	56	23,767
Missaukee	14,849	LOW	14	0.79	0	0	4,713
Monroe	152,021	MEDIUM	74	4.15	0	0	26,617
Montcalm	63,342	MEDIUM	25	1.40	1,280,000	71,789	106,737
Montmorency	9,765	MEDIUM	25	1.40	0	0	19,274
Muskegon	172,188	MEDIUM	40	2.24	675,000	37,858	150,609
Newaygo	48,460	MEDIUM	28	1.57	395,000	22,154	80,669
Oakland	1,202,362	MEDIUM	147	8.24	11,000	617	16,291

Loss Estimation for the State of Michigan: Hail – cont.

COUNTY	Population*	Relative Risk	Number of Damaging Hailstorms: 1996-2013 (NCDC)	Expected Annual Events	Historic Hailstorm Damage ($) (NCDC)	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Oceana	26,570	MEDIUM	21	1.18	315,000	17,667	71,143
Ogemaw	21,699	LOW	35	1.96	0	0	1,291
Ontonagon	6,780	MEDIUM	45	2.52	0	0	190,906
Osceola	23,528	MEDIUM	14	0.79	145,000	8,132	26,241
Oscoda	8,640	MEDIUM	34	1.91	0	0	8,180
Otsego	24,164	MEDIUM	36	2.02	0	0	7,529
Ottawa	263,801	HIGH	53	2.97	794,000	44,532	617,665
Presque Isle	13,376	MEDIUM	26	1.46	3,800,000	213,124	38,448
Roscommon	24,449	LOW	31	1.74	0	0	3,254
Saginaw	200,169	MEDIUM	86	4.82	300	17	30,861
St. Clair	163,040	LOW	71	3.98	125,000	7,011	2,864
St. Joseph	61,295	HIGH	41	2.30	0	0	1,532,297
Sanilac	43,114	LOW	49	2.75	165,000	9,254	2,875
Schoolcraft	8,485	HIGH	32	1.79	100,000	5,609	291,477
Shiawassee	70,648	MEDIUM	36	2.02	4,800,000	269,209	59,779
Tuscola	55,729	MEDIUM	65	3.65	0	0	12,776
Van Buren	76,258	HIGH	26	1.46	50,585,000	2,837,072	1,594,716
Washtenaw	344,791	MEDIUM	154	8.64	10,000	561	28,962
Wayne	1,820,584	MEDIUM	146	8.19	7,000	393	10,977
Wexford	32,735	LOW	22	1.23	0	0	4,815
MI TOTAL	9,883,640		3,612	202.58	295,752,300	16,587,342	

Notes: *2010 Census


Expected Annual Losses
Hail
Relative Risk
$0 - $4,999 (Low)
$5,000 - $199,999 (Medium)
$200,000 - $1,594,716 (High)

Loss Estimation for the State of Michigan: Lightning

COUNTY	Population*	Relative Risk	Number of Damaging Lightning Events: 1996-2013 (NCDC)	Expected Annual Events	Historic Lightning Damage ($) (NCDC)	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Alcona	10,942	LOW		0.00		0	1,417
Alger	9,601	LOW	2	0.11		0	1,754
Allegan	111,408	MEDIUM		0.00		0	9,347
Alpena	29,598	LOW	1	0.06		0	1,789
Antrim	23,580	MEDIUM	2	0.11	80,000	4,487	5,129
Arenac	15,899	LOW	1	0.06	500	28	1,410
Baraga	8,860	LOW		0.00		0	1,717
Barry	59,173	MEDIUM	1	0.06		0	5,571
Bay	107,771	MEDIUM	5	0.28	63,000	3,533	6,172
Benzie	17,525	LOW	1	0.06		0	2,222
Berrien	156,813	MEDIUM	3	0.17	840,000	47,112	13,953
Branch	45,248	LOW		0.00		0	3,075
Calhoun	136,146	MEDIUM	1	0.06	11,000	617	6,957
Cass	52,293	MEDIUM		0.00		0	9,226
Charlevoix	25,949	MEDIUM	1	0.06		0	5,290
Cheboygan	26,152	LOW	2	0.11	75,000	4,206	3,992
Chippewa	38,520	LOW	1	0.06	2,800	157	3,335
Clare	30,926	LOW	1	0.06	5,000	280	1,382
Clinton	75,382	MEDIUM		0.00		0	8,700
Crawford	14,074	LOW	1	0.06		0	3,500
Delta	37,069	LOW		0.00		0	1,849
Dickinson	26,168	LOW	3	0.17	171,000	9,591	2,761
Eaton	107,759	MEDIUM		0.00		0	9,981
Emmet	32,694	LOW	1	0.06	4,000	224	4,933
Genesee	425,790	MEDIUM	14	0.79	220,500	12,367	42,022
Gladwin	25,692	LOW	1	0.06		0	1,550
Gogebic	16,427	LOW	2	0.11		0	1,429
Gd. Traverse	86,986	LOW	6	0.34	170,000	9,534	3,180
Gratiot	42,476	MEDIUM		0.00		0	6,536
Hillsdale	46,688	MEDIUM	1	0.06		0	14,986
Houghton	36,628	LOW	2	0.11	25,000	1,402	1,304
Huron	33,118	MEDIUM	3	0.17	535,000	30,006	19,775

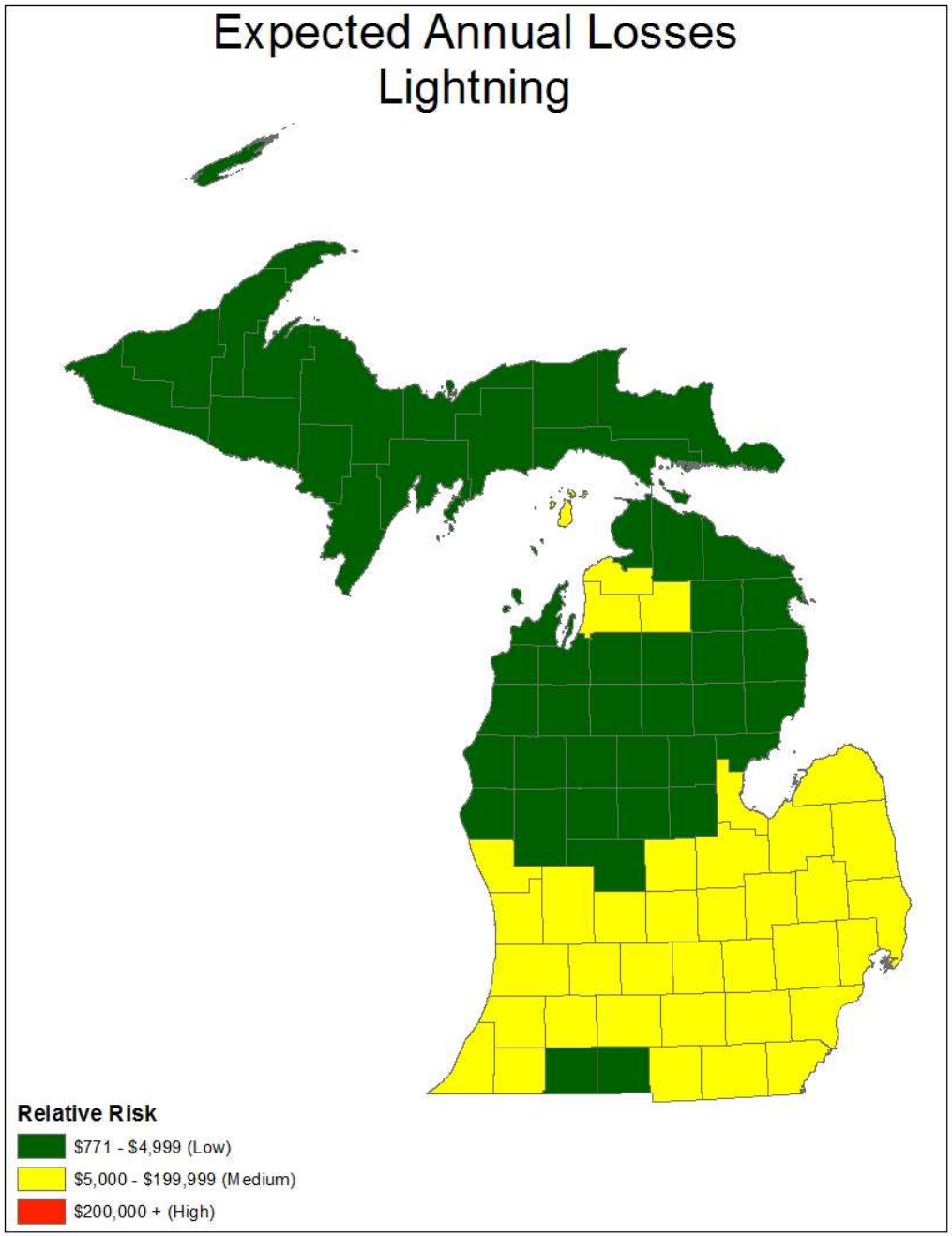
Loss Estimation for the State of Michigan: Lightning – cont.

COUNTY	Population *	Relative Risk	Number of Damaging Lightning Events: 1996-2013 (NCDC)	Expected Annual Events	Historic Lightning Damage ($) (NCDC)	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Ingham	280,895	MEDIUM		0.00		0	20,772
Ionia	63,905	MEDIUM	1	0.06		0	5,467
Iosco	25,887	LOW	3	0.17	15,000	841	1,052
Iron	11,817	LOW	1	0.06	50,000	2,804	1,789
Isabella	70,311	LOW	1	0.06	10,000	561	2,587
Jackson	160,248	MEDIUM		0.00		0	25,720
Kalamazoo	250,331	MEDIUM	3	0.17	20,000	1,122	6,003
Kalkaska	17,153	LOW	2	0.11		0	3,324
Kent	602,622	MEDIUM	3	0.17	1,000,000	56,085	10,135
Keweenaw	2,156	LOW		0.00		0	771
Lake	11,539	LOW		0.00		0	2,054
Lapeer	88,319	MEDIUM	9	0.50	1,328,000	74,481	54,567
Leelanau	21,708	LOW	2	0.11	40,000	2,243	2,774
Lenawee	99,892	MEDIUM	18	1.01	880,000	49,355	36,416
Livingston	180,967	MEDIUM	12	0.67	1,844,000	103,421	45,937
Luce	6,631	LOW	1	0.06	70,000	3,926	2,744
Mackinac	11,113	LOW	1	0.06	150,000	8,413	3,674
Macomb	840,978	MEDIUM	25	1.40	2,927,000	164,162	74,869
Manistee	24,733	LOW	1	0.06		0	1,559
Marquette	67,077	LOW	4	0.22	41,000	2,299	2,054
Mason	28,705	LOW		0.00		0	2,550
Mecosta	42,798	LOW	2	0.11	50,000	2,804	3,053
Menominee	24,029	LOW		0.00		0	2,301
Midland	83,629	LOW	6	0.34	70,000	3,926	3,030
Missaukee	14,849	LOW	3	0.17	1,000	56	2,180
Monroe	152,021	MEDIUM	8	0.45	143,000	8,020	56,813
Montcalm	63,342	LOW	1	0.06		0	4,950
Montmorency	9,765	LOW		0.00		0	2,929
Muskegon	172,188	MEDIUM	1	0.06	40,000	2,243	9,257
Newaygo	48,460	LOW	1	0.06	100,000	5,609	4,850
Oakland	1,202,362	MEDIUM	39	2.19	2,318,000	130,006	67,761

Loss Estimation for the State of Michigan: Lightning – cont.

COUNTY	Population*	Relative Risk	Number of Damaging Lightning Events: 1996-2013 (NCDC)	Expected Annual Events	Historic Lightning Damage ($) (NCDC)	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Oceana	26,570	LOW		0.00		0	4,924
Ogemaw	21,699	LOW	1	0.06		0	1,387
Ontonagon	6,780	LOW		0.00		0	1,282
Osceola	23,528	LOW		0.00		0	2,007
Oscoda	8,640	LOW	2	0.11		0	1,947
Otsego	24,164	MEDIUM	4	0.22	503,000	28,211	5,285
Ottawa	263,801	MEDIUM	3	0.17	60,000	3,365	12,315
Presque Isle	13,376	LOW	2	0.11	4,000	224	2,782
Roscommon	24,449	LOW	2	0.11	55,000	3,085	2,316
Saginaw	200,169	MEDIUM	7	0.39	202,500	11,357	15,461
St. Clair	163,040	MEDIUM	6	0.34	28,000	1,570	55,739
St. Joseph	61,295	LOW	5	0.28	30,000	1,683	4,633
Sanilac	43,114	MEDIUM	5	0.28	145,000	8,132	35,606
Schoolcraft	8,485	LOW		0.00		0	2,002
Shiawassee	70,648	MEDIUM	6	0.34	225,000	12,619	21,886
Tuscola	55,729	MEDIUM	1	0.06	100,000	5,609	25,294
Van Buren	76,258	MEDIUM	2	0.11	200,000	11,217	9,682
Washtenaw	344,791	MEDIUM	20	1.12	1,820,000	102,075	56,990
Wayne	1,820,584	MEDIUM	20	1.12	557,000	31,239	72,781
Wexford	32,735	LOW	1	0.06		0	2,086
MI TOTAL	9,883,640		291	16.32	17,229,300	966,310	

Notes: *2010 Census


Expected Annual Losses
Lightning
Relative Risk
$771 - $4,999 (Low)
$5,000 - $199,999 (Medium)
$200,000 + (High)

Loss Estimation for the State of Michigan: Snowstorms

COUNTY	Population*	Relative Risk	Number of Snowstorms: 1996-2013 (NCDC)	Expected Annual Events	Adjusted Historic Snowstorm Damage ($) NCDC	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Alcona	10,942	MEDIUM	39	2.19	3,000	168	5,353
Alger	9,601	LOW	192	10.77	11,000	617	3,804
Allegan	111,408	MEDIUM	130	7.29	25,000	1,402	9,290
Alpena	29,598	MEDIUM	55	3.08	110,000	6,169	7,581
Antrim	23,580	MEDIUM	122	6.84	250,000	14,021	27,960
Arenac	15,899	LOW	38	2.13	0	0	2,109
Baraga	8,860	MEDIUM	118	6.62	6,000	0	8,678
Barry	59,173	MEDIUM	61	3.42	25,000	1,402	21,713
Bay	107,771	MEDIUM	46	2.58	25,000	1,402	8,493
Benzie	17,525	MEDIUM	79	4.43	2,600,000	0	108,824
Berrien	156,813	LOW	83	4.66	20,000	1,122	838
Branch	45,248	MEDIUM	40	2.24	0	0	27,687
Calhoun	136,146	MEDIUM	52	2.92	2,225,000	124,790	32,820
Cass	52,293	MEDIUM	72	4.04	0	0	8,016
Charlevoix	25,949	MEDIUM	110	6.17	295,000	16,545	13,291
Cheboygan	26,152	MEDIUM	71	3.98	206,000	11,554	11,057
Chippewa	38,520	LOW	98	5.50	85,000	4,767	2,710
Clare	30,926	MEDIUM	52	2.92	300,000	16,826	9,421
Clinton	75,382	MEDIUM	40	2.24	1,025,000	57,487	26,934
Crawford	14,074	MEDIUM	66	3.70	255,000	14,302	9,817
Delta	37,069	LOW	94	5.27	75,000	4,206	4,489
Dickinson	26,168	MEDIUM	68	3.81	20,000	1,122	8,308
Eaton	107,759	MEDIUM	45	2.52	1,025,000	57,487	34,280
Emmet	32,694	MEDIUM	91	5.10	204,000	11,441	13,270
Genesee	425,790	MEDIUM	49	2.75	1,650,000	92,541	24,639
Gladwin	25,692	MEDIUM	35	1.96	0	0	5,012
Gogebic	16,427	MEDIUM	167	9.37	63,000	3,533	10,039
Gd. Traverse	86,986	MEDIUM	93	5.22	5,612,000	0	72,682
Gratiot	42,476	MEDIUM	46	2.58	25,000	1,402	15,300
Hillsdale	46,688	MEDIUM	35	1.96	0	0	33,486
Houghton	36,628	MEDIUM	44	2.47	0	0	7,291
Huron	33,118	MEDIUM	54	3.03	1,500,000	84,128	23,798

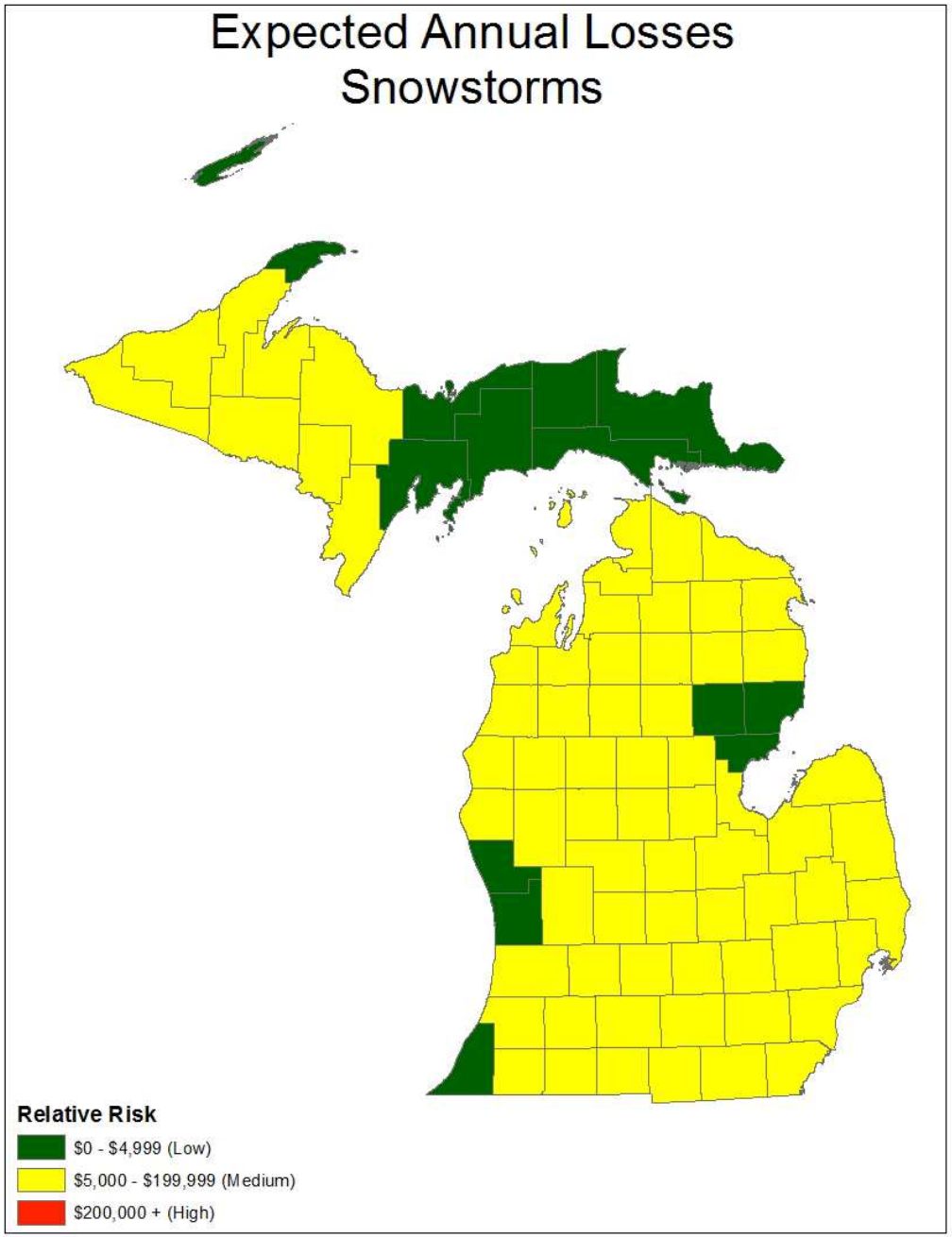
Loss Estimation for the State of Michigan: Snowstorms – cont.

COUNTY	Population *	Relative Risk	Number of Snowstorms: 1996-2013 (NCDC)	Expected Annual Events	Adjusted Historic Snowstorm Damage ($) NCDC	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Ingham	280,895	MEDIUM	46	2.58	1,025,000	57,487	38,639
Ionia	63,905	MEDIUM	46	2.58	25,000	1,402	20,910
Iosco	25,887	LOW	42	2.36	0	0	3,155
Iron	11,817	MEDIUM	66	3.70	605,000	33,932	9,947
Isabella	70,311	MEDIUM	49	2.75	290,000	16,265	9,366
Jackson	160,248	MEDIUM	47	2.64	1,200,000	67,302	37,607
Kalamazoo	250,331	MEDIUM	73	4.09	25,000	1,402	15,876
Kalkaska	17,153	MEDIUM	106	5.95	290,000	16,265	23,537
Kent	602,622	MEDIUM	87	4.88	50,000	2,804	9,609
Keweenaw	2,156	LOW	160	8.97	0	0	3,483
Lake	11,539	MEDIUM	71	3.98	375,000	21,032	10,058
Lapeer	88,319	MEDIUM	46	2.58	10,000	561	18,392
Leelanau	21,708	MEDIUM	102	5.72	13,653,000	765,732	173,576
Lenawee	99,892	MEDIUM	42	2.36	505,000	28,323	32,545
Livingston	180,967	MEDIUM	47	2.64	129,000	7,235	32,566
Luce	6,631	LOW	119	6.67	3,500	196	2,728
Mackinac	11,113	LOW	58	3.25	50,000	2,804	4,367
Macomb	840,978	MEDIUM	43	2.41	170,000	9,534	17,572
Manistee	24,733	MEDIUM	72	4.04	350,000	19,630	51,398
Marquette	67,077	MEDIUM	154	8.64	262,000	14,694	7,616
Mason	28,705	MEDIUM	99	5.55	0	0	7,968
Mecosta	42,798	MEDIUM	56	3.14	40,000	2,243	10,347
Menominee	24,029	MEDIUM	71	3.98	7,000	393	7,368
Midland	83,629	MEDIUM	45	2.52	0	0	7,436
Missaukee	14,849	MEDIUM	63	3.53	185,000	10,376	23,127
Monroe	152,021	MEDIUM	33	1.85	45,000	2,524	23,606
Montcalm	63,342	MEDIUM	58	3.25	30,000	1,683	11,753
Montmorency	9,765	MEDIUM	48	2.69	165,000	9,254	9,190
Muskegon	172,188	LOW	102	5.72	0	0	4,425
Newaygo	48,460	MEDIUM	69	3.87	25,000	1,402	8,258
Oakland	1,202,362	MEDIUM	49	2.75	400,000	22,434	23,911

Loss Estimation for the State of Michigan: Snowstorms – cont.

COUNTY	Population*	Relative Risk	Number of Snowstorms: 1996-2013 (NCDC)	Expected Annual Events	Adjusted Historic Snowstorm Damage ($) NCDC	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Oceana	26,570	MEDIUM	100	5.61	0	0	6,812
Ogemaw	21,699	LOW	45	2.52	50,000	2,804	4,860
Ontonagon	6,780	MEDIUM	200	11.22	16,000	897	9,271
Osceola	23,528	MEDIUM	56	3.14	510,000	28,603	11,074
Oscoda	8,640	MEDIUM	46	2.58	100,000	5,609	7,097
Otsego	24,164	MEDIUM	101	5.66	337,000	18,901	11,384
Ottawa	263,801	LOW	122	6.84	250,000	14,021	3,739
Presque Isle	13,376	MEDIUM	55	3.08	258,000	14,470	9,922
Roscommon	24,449	MEDIUM	52	2.92	100,000	0	8,201
Saginaw	200,169	MEDIUM	48	2.69	25,000	1,402	14,923
St. Clair	163,040	MEDIUM	57	3.20	45,000	2,524	14,193
St. Joseph	61,295	MEDIUM	42	2.36	0	0	16,004
Sanilac	43,114	MEDIUM	59	3.31	5,000	280	18,577
Schoolcraft	8,485	LOW	19	1.07	0	0	3,006
Shiawassee	70,648	MEDIUM	39	2.19	10,000	561	25,242
Tuscola	55,729	MEDIUM	46	2.58	0	0	17,407
Van Buren	76,258	MEDIUM	111	6.23	25,000	1,402	7,303
Washtenaw	344,791	MEDIUM	45	2.52	225,000	12,619	29,199
Wayne	1,820,584	MEDIUM	38	2.13	960,000	53,842	23,689
Wexford	32,735	MEDIUM	57	3.20	283,000	15,872	42,256
MI TOTAL	9,883,640		6,261	351.15	40,798,500	2,288,194	

Notes: *2010 Census


Expected Annual Losses
Snowstorms
Relative Risk
$0 - $4,999 (Low)
$5,000 - $199,999 (Medium)
$200,000 + (High)

Loss Estimation for the State of Michigan: Ice/Sleet Storms

COUNTY	Population*	Relative Risk	Number of Ice/Sleet Storms: 1996-2013 (NCDC)	Average Number of Ice/Sleet Storms per Year	Adjusted Historic Ice/Sleet Storms Damage ($) NCDC	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Alcona	10,942	LOW	3	0.17	0	0	532
Alger	9,601	LOW	4	0.22	0	0	0
Allegan	111,408	MEDIUM	6	0.34	0	0	12,304
Alpena	29,598	LOW	2	0.11	0	0	171
Antrim	23,580	LOW	3	0.17	0	0	5
Arenac	15,899	LOW	2	0.11	50,000	2,804	4,125
Baraga	8,860	LOW	3	0.17	0	0	0
Barry	59,173	MEDIUM	6	0.34	25,000	1,402	12,983
Bay	107,771	MEDIUM	11	0.62	0	0	13,331
Benzie	17,525	LOW	4	0.22	0	0	1,666
Berrien	156,813	LOW	9	0.50	30,000	1,683	1,832
Branch	45,248	MEDIUM	9	0.50	0	0	7,492
Calhoun	136,146	MEDIUM	6	0.34	30,000	1,683	15,739
Cass	52,293	LOW	9	0.50	30,000	1,683	1,756
Charlevoix	25,949	LOW	3	0.17	0	0	0
Cheboygan	26,152	LOW	4	0.22	0	0	0
Chippewa	38,520	LOW	3	0.17	0	0	0
Clare	30,926	MEDIUM	4	0.22	355,000	19,910	12,691
Clinton	75,382	MEDIUM	7	0.39	330,000	18,508	26,861
Crawford	14,074	LOW	1	0.06	0	0	1,128
Delta	37,069	LOW	4	0.22	0	0	0
Dickinson	26,168	LOW	5	0.28	0	0	0
Eaton	107,759	MEDIUM	7	0.39	325,000	18,228	24,753
Emmet	32,694	LOW	4	0.22	0	0	0
Genesee	425,790	HIGH	8	0.45	110,000	6,169	652,904
Gladwin	25,692	MEDIUM	3	0.17	60,000	3,365	9,883
Gogebic	16,427	LOW	3	0.17	0	0	0
Gd. Traverse	86,986	LOW	4	0.22	0	0	1,751
Gratiot	42,476	MEDIUM	7	0.39	1,255,000	70,387	26,292
Hillsdale	46,688	MEDIUM	9	0.50	0	0	42,961
Houghton	36,628	LOW	1	0.06	0	0	0
Huron	33,118	MEDIUM	8	0.45	25,000	1,402	48,594

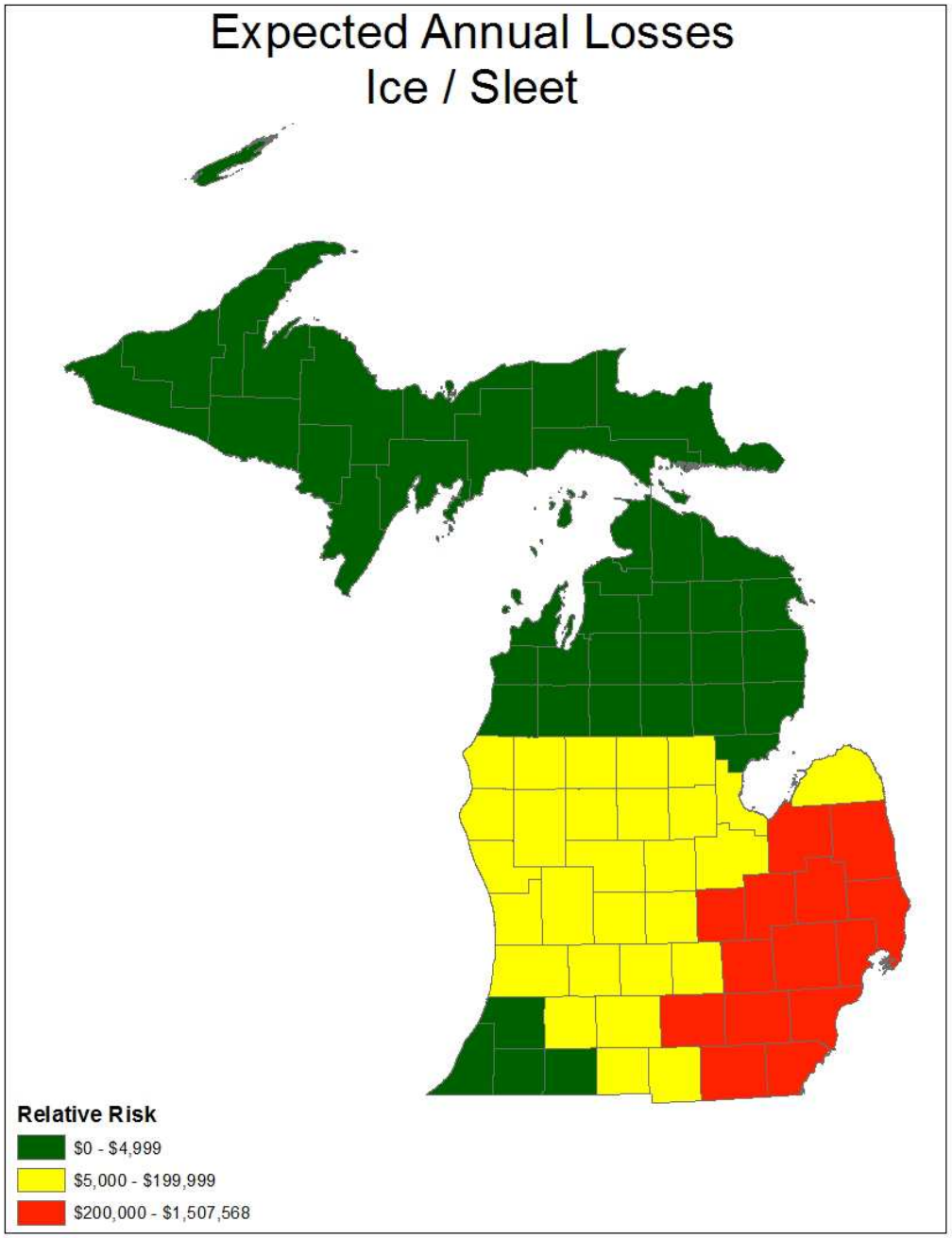
Loss Estimation for the State of Michigan: Ice/Sleet Storms – cont.

COUNTY	Population *	Relative Risk	Number of Ice/Sleet Storms: 1996-2013 (NCDC)	Expected Annual Events	Adjusted Historic Ice/Sleet Storms Damage ($) NCDC	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Ingham	280,895	MEDIUM	7	0.39	340,000	19,069	176,164
Ionia	63,905	MEDIUM	8	0.45	330,000	18,508	20,780
Iosco	25,887	LOW	4	0.22	50,000	2,804	1,008
Iron	11,817	LOW	3	0.17	0	0	0
Isabella	70,311	MEDIUM	8	0.45	355,000	19,910	18,190
Jackson	160,248	HIGH	6	0.34	30,000	1,683	265,229
Kalamazoo	250,331	MEDIUM	6	0.34	75,000	4,206	5,226
Kalkaska	17,153	LOW	4	0.22	0	0	1,656
Kent	602,622	MEDIUM	8	0.45	1,000,000	56,085	20,668
Keweenaw	2,156	LOW	2	0.11	0	0	0
Lake	11,539	MEDIUM	1	0.06	200,000	11,217	10,235
Lapeer	88,319	HIGH	8	0.45	1,075,000	60,292	947,030
Leelanau	21,708	LOW	4	0.22	0	0	0
Lenawee	99,892	HIGH	8	0.45	2,530,000	141,896	281,235
Livingston	180,967	HIGH	7	0.39	2,310,000	129,557	606,228
Luce	6,631	LOW	5	0.28	0	0	0
Mackinac	11,113	LOW	3	0.17	0	0	0
Macomb	840,978	HIGH	8	0.45	54,325,000	3,046,831	1,507,568
Manistee	24,733	LOW	4	0.22	0	0	4,158
Marquette	67,077	LOW	4	0.22	0	0	0
Mason	28,705	MEDIUM	1	0.06	200,000	11,217	9,368
Mecosta	42,798	MEDIUM	8	0.45	355,000	19,910	16,916
Menominee	24,029	LOW	4	0.22	0	0	0
Midland	83,629	MEDIUM	11	0.62	0	0	16,671
Missaukee	14,849	LOW	2	0.11	0	0	4,723
Monroe	152,021	HIGH	8	0.45	4,540,000	254,627	810,108
Montcalm	63,342	MEDIUM	8	0.45	200,000	11,217	21,955
Montmorency	9,765	LOW	3	0.17	0	0	111
Muskegon	172,188	MEDIUM	6	0.34	200,000	11,217	17,769
Newaygo	48,460	MEDIUM	2	0.11	200,000	11,217	15,588
Oakland	1,202,362	HIGH	8	0.45	104,452,000	5,858,216	1,336,891

Loss Estimation for the State of Michigan: Ice/Sleet Storms – cont.

COUNTY	Population*	Relative Risk	Number of Ice/Sleet Storms: 1996-2013 (NCDC)	Expected Annual Events	Adjusted Historic Ice/Sleet Storms Damage ($) NCDC	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Oceana	26,570	MEDIUM	2	0.11	200,000	0	12,882
Ogemaw	21,699	LOW	3	0.17	5,000	280	1,725
Ontonagon	6,780	LOW	3	0.17	0	0	0
Osceola	23,528	MEDIUM	4	0.22	455,000	25,519	12,558
Oscoda	8,640	LOW	2	0.11	0	0	685
Otsego	24,164	LOW	3	0.17	0	0	47
Ottawa	263,801	MEDIUM	8	0.45	500,000	28,043	19,387
Presque Isle	13,376	LOW	4	0.22	0	0	0
Roscommon	24,449	LOW	3	0.17	0	0	3,377
Saginaw	200,169	MEDIUM	12	0.67	1,010,000	56,646	144,685
St. Clair	163,040	HIGH	8	0.45	10,100,000	566,461	1,092,605
St. Joseph	61,295	LOW	10	0.56	30,000	1,683	2,053
Sanilac	43,114	HIGH	7	0.39	30,000	1,683	485,513
Schoolcraft	8,485	LOW	4	0.22	0	0	0
Shiawassee	70,648	HIGH	8	0.45	0	0	271,367
Tuscola	55,729	HIGH	9	0.50	20,000	1,122	344,534
Van Buren	76,258	LOW	6	0.34	25,000	1,402	3,995
Washtenaw	344,791	HIGH	7	0.39	3,400,000	190,690	793,889
Wayne	1,820,584	HIGH	8	0.45	5,000,000	280,426	1,290,511
Wexford	32,735	LOW	3	0.17	0	0	4,669
MI TOTAL	9,883,640		294	16.49	196,167,000	11,002,075	

Notes: *2010 Census


Expected Annual Losses
Ice / Sleet
Relative Risk
$0 - $4,999
$5,000 - $199,999
$200,000 - $1,507,568

Loss Estimation for the State of Michigan: Wildfires

COUNTY	Population*	Relative Risk	Number of Wildfires: 1996-2013 (NCDC)	Expected Annual Events	Adjusted Historic Wildfires Damage ($) NCDC	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Alcona	10,942	MEDIUM		0.00	0.00	0	10,745
Alger	9,601	MEDIUM		0.00	0.00	0	117,684
Allegan	111,408	LOW		0.00	0.00	0	0
Alpena	29,598	MEDIUM		0.00	0.00	0	8,353
Antrim	23,580	MEDIUM		0.00	0.00	0	9,857
Arenac	15,899	LOW		0.00	0.00	0	4,631
Baraga	8,860	MEDIUM	2	0.11	0.05	2,804	45,629
Barry	59,173	LOW		0.00	0.00	0	0
Bay	107,771	LOW		0.00	0.00	0	75
Benzie	17,525	LOW		0.00	0.00	0	351
Berrien	156,813	LOW		0.00	0.00	0	0
Branch	45,248	LOW		0.00	0.00	0	0
Calhoun	136,146	LOW		0.00	0.00	0	0
Cass	52,293	LOW		0.00	0.00	0	0
Charlevoix	25,949	MEDIUM		0.00	0.00	0	6,403
Cheboygan	26,152	MEDIUM		0.00	0.00	0	23,775
Chippewa	38,520	MEDIUM		0.00	0.00	0	165,065
Clare	30,926	LOW		0.00	0.00	0	3,505
Clinton	75,382	LOW		0.00	0.00	0	0
Crawford	14,074	MEDIUM	2	0.11	1.58	88,334	14,543
Delta	37,069	MEDIUM		0.00	0.00	0	107,516
Dickinson	26,168	MEDIUM		0.00	0.00	0	66,367
Eaton	107,759	LOW		0.00	0.00	0	0
Emmet	32,694	LOW		0.00	0.00	0	0
Genesee	425,790	LOW		0.00	0.00	0	46
Gladwin	25,692	LOW		0.00	0.00	0	4,013
Gogebic	16,427	MEDIUM		0.00	0.00	0	16,174
Gd. Traverse	86,986	MEDIUM		0.00	0.00	0	5,185
Gratiot	42,476	LOW		0.00	0.00	0	0
Hillsdale	46,688	LOW		0.00	0.00	0	0
Houghton	36,628	MEDIUM		0.00	0.00	0	26,799
Huron	33,118	LOW		0.00	25,000	1,402	0

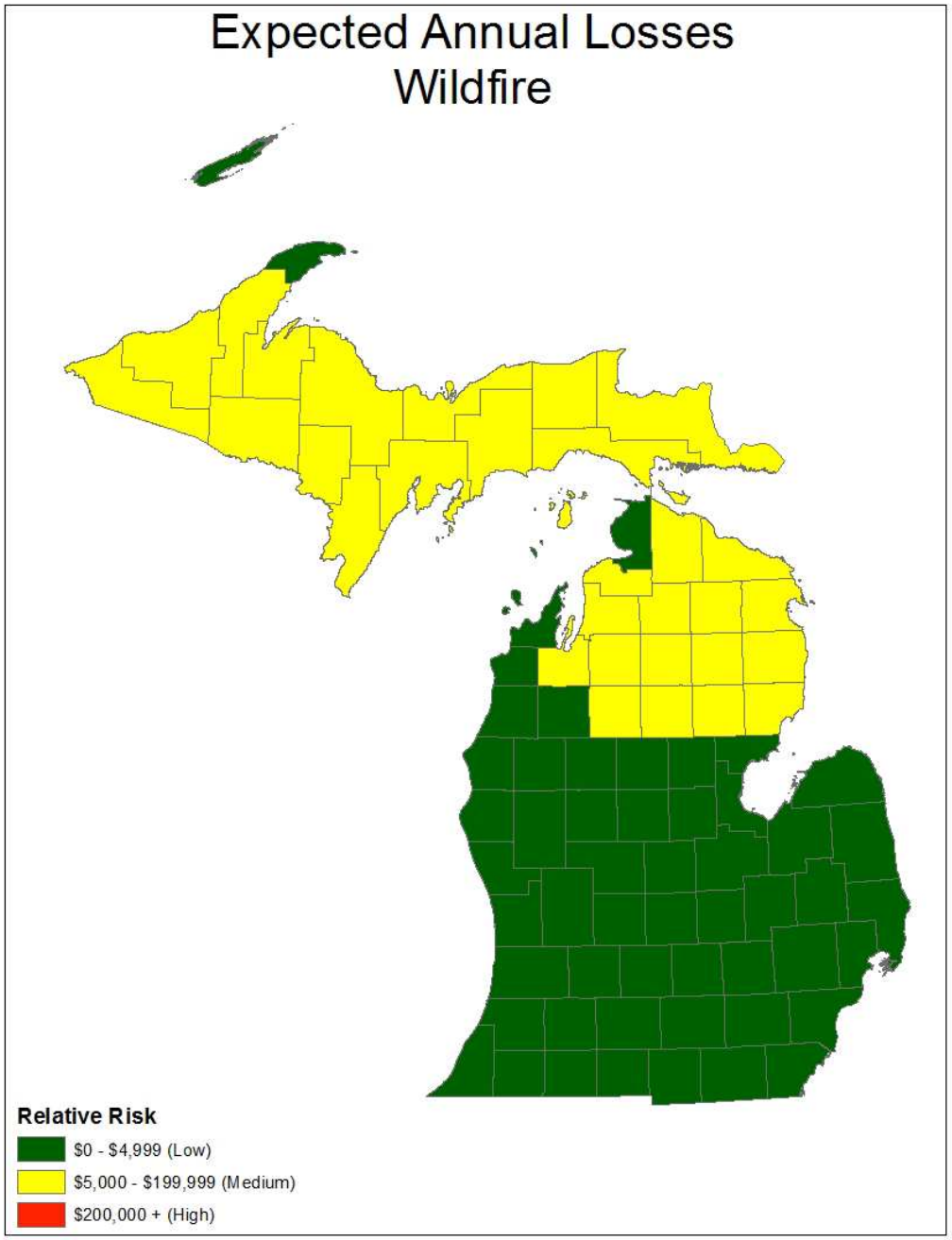
Loss Estimation for the State of Michigan: Wildfires – cont.

COUNTY	Population*	Relative Risk	Number of Wildfires: 1996-2013 (NCDC)	Expected Annual Events	Adjusted Historic Wildfires Damage ($) NCDC	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Ingham	280,895	LOW		0.00	0.00	0	0
Ionia	63,905	LOW		0.00	0.00	0	0
Iosco	25,887	MEDIUM	1	0.06	0.04	2,243	8,588
Iron	11,817	MEDIUM		0.00	0.00	0	38,104
Isabella	70,311	LOW		0.00	0.00	0	0
Jackson	160,248	LOW		0.00	0.00	0	0
Kalamazoo	250,331	LOW		0.00	0.00	0	0
Kalkaska	17,153	MEDIUM	1	0.06	0.13	7,011	11,008
Kent	602,622	LOW		0.00	0.00	0	0
Keweenaw	2,156	LOW		0.00	0.00	0	280
Lake	11,539	LOW		0.00	0.00	0	110
Lapeer	88,319	LOW		0.00	0.00	0	118
Leelanau	21,708	LOW		0.00	0.00	0	292
Lenawee	99,892	LOW		0.00	0.00	0	0
Livingston	180,967	LOW		0.00	0.00	0	23
Luce	6,631	MEDIUM	2	0.11	12.04	675,266	166,534
Mackinac	11,113	MEDIUM		0.00	0.00	0	126,050
Macomb	840,978	LOW	2	0.11	0.02	1,122	210
Manistee	24,733	LOW		0.00	0.00	0	292
Marquette	67,077	MEDIUM	7	0.39	6.01	336,848	88,596
Mason	28,705	LOW		0.00	0.00	0	0
Mecosta	42,798	LOW		0.00	0.00	0	0
Menominee	24,029	MEDIUM		0.00	0.00	0	71,079
Midland	83,629	LOW		0.00	0.00	0	0
Missaukee	14,849	MEDIUM		0.00	0.00	0	7,006
Monroe	152,021	LOW		0.00	0.00	0	56
Montcalm	63,342	LOW		0.00	0.00	0	0
Montmorency	9,765	MEDIUM		0.00	0.00	0	9,028
Muskegon	172,188	LOW		0.00	0.00	0	0
Newaygo	48,460	LOW		0.00	0.00	0	0
Oakland	1,202,362	LOW		0.00	0.00	0	110

Loss Estimation for the State of Michigan: Wildfires – cont.

COUNTY	Population*	Relative Risk	Number of Wildfires: 1996-2013 (NCDC)	Expected Annual Events	Adjusted Historic Wildfires Damage ($) NCDC	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Oceana	26,570	LOW		0.00	0.00	0	0
Ogemaw	21,699	MEDIUM		0.00	0.00	0	9,175
Ontonagon	6,780	MEDIUM	1	0.06	0.00	0	12,271
Osceola	23,528	LOW		0.00	0.00	0	1,599
Oscoda	8,640	MEDIUM	2	0.11	0.60	33,651	12,339
Otsego	24,164	MEDIUM		0.00	0.00	0	10,915
Ottawa	263,801	LOW		0.00	0.00	0	0
Presque Isle	13,376	MEDIUM		0.00	0.00	0	5,495
Roscommon	24,449	MEDIUM	1	0.06	0.00	0	10,453
Saginaw	200,169	LOW		0.00	0.00	0	0
St. Clair	163,040	LOW		0.00	0.00	0	166
St. Joseph	61,295	LOW		0.00	0.00	0	0
Sanilac	43,114	LOW		0.00	0.00	0	88
Schoolcraft	8,485	MEDIUM		0.00	0.00	0	134,990
Shiawassee	70,648	LOW		0.00	0.00	0	0
Tuscola	55,729	LOW	1	0.06	0.00	0	23
Van Buren	76,258	LOW		0.00	0.00	0	0
Washtenaw	344,791	LOW		0.00	0.00	0	55
Wayne	1,820,584	LOW		0.00	0.00	0	122
Wexford	32,735	LOW		0.00	0.00	0	3,199
MI TOTAL	9,883,640		23	1.29	20.46	1,147,280	

Notes: *2010 Census


Expected Annual Losses
Wildfire
Relative Risk
$0 - $4,999 (Low)
$5,000 - $199,999 (Medium)
$200,000 + (High)

Extreme Cold Temperatures for the State of Michigan: Risk / Probability of Occurrence

COUNTY	Population*	Relative Risk	Date of Record Cold Temperature	Record Cold Temperature °F	Number of Days Annually < 0° F**	Probability of Occurrence (%)
Alcona	10,942	MEDIUM	12/28/1977	-28	13.4	3.7
Alger	9,601	HIGH	7/7/1936	-33	20.7	5.7
Allegan	111,408	LOW	2/10/1912	-29	9.6	2.6
Alpena	29,598	HIGH	2/17/1979	-37	19.6	5.4
Antrim	23,580	HIGH	2/17/1979	-41	19	5.2
Arenac	15,899	MEDIUM	2/1/1994	-28	18.8	5.1
Baraga	8,860	HIGH	2/17/1979	-40	38.4	10.5
Barry	59,173	MEDIUM	1/4/1896	-40	11.7	3.2
Bay	107,771	LOW	1/19/1994	-18	6.7	1.8
Benzie	17,525	LOW	2/11/1889	-32	3.6	1.0
Berrien	156,813	LOW	1/12/1918	-21	4.7	1.3
Branch	45,248	MEDIUM	1/4/1981	-23	10	2.7
Calhoun	136,146	LOW	2/12/1899	-24	8.3	2.3
Cass	52,293	LOW	2/7/1978	-23	8.9	2.4
Charlevoix	25,949	MEDIUM	2/17/1979	-35	18.4	5.0
Cheboygan	26,152	HIGH	2/9/1934	-35	20.9	5.7
Chippewa	38,520	HIGH	2/8/1934	-37	31.7	8.7
Clare	30,926	HIGH	2/20/1929	-39	21.6	5.9
Clinton	75,382	LOW	2/2/1895	-42	9.4	2.6
Crawford	14,074	HIGH	2/17/1979	-42	30.6	8.4
Delta	37,069	HIGH	2/17/1979	-30	22.9	6.3
Dickinson	26,168	HIGH	2/3/1996	-45	37.7	10.3
Eaton	107,759	MEDIUM	2/10/1912	-31	13.5	3.7
Emmet	32,694	MEDIUM	2/9/1934	-35	10.7	2.9
Genesee	425,790	MEDIUM	2/14/1916	-28	10.5	2.9
Gladwin	25,692	MEDIUM	2/20/1929	-39	18.9	5.2
Gogebic	16,427	HIGH	1/17/1982	-41	44.3	12.1
Gd Traverse	86,986	MEDIUM	2/17/1979	-37	11	3.0
Gratiot	42,476	MEDIUM	2/5/1918	-29	10.1	2.8
Hillsdale	46,688	MEDIUM	2/11/1912	-25	12.6	3.4
Houghton	36,628	MEDIUM	2/4/1996	-28	18	4.9
Huron	33,118	LOW	1/30/1951	-23	9.4	2.6
Ingham	280,895	MEDIUM	1/4/1981	-29	13.1	3.6
Ionia	63,905	MEDIUM	1/15/1963	-25	10.4	2.8
Iosco	25,887	MEDIUM	4/7/1904	-34	16.3	4.5
Iron	11,817	HIGH	2/17/1979	-42	55.1	15.1
Isabella	70,311	LOW	2/5/1918	-30	9.9	2.7
Jackson	160,248	LOW	2/10/1912	-21	9.4	2.6
Kalamazoo	250,331	LOW	2/10/1912	-22	5.3	1.5
Kalkaska	17,153	HIGH	2/4/1996	-34	21	5.7
Kent	602,622	LOW	2/13/1899	-24	7.9	2.2
Keweenaw	2,156	MEDIUM	3/6/2003	-23	13.4	3.7
Lake	11,539	HIGH	2/11/1999	-49	21.3	5.8

Extreme Cold Temperatures for the State of Michigan: Risk / Probability of Occurrence – cont.

COUNTY	Population*	Relative Risk	Date of Record Cold Temperature	Record Cold Temperature °F	Number of Days Annually < 0° F**	Probability of Occurrence (%)
Lapeer	88,319	MEDIUM	1/11/1984	-26	11.5	3.1
Leelanau	21,708	LOW	2/17/1979	-24	8.5	2.3
Lenawee	99,892	MEDIUM	1/20/1992	-26	10.2	2.8
Livingston	180,967	MEDIUM	1/19/1994	-23	11.3	3.1
Luce	6,631	HIGH	2/7/1899	-32	24.5	6.7
Mackinac	11,113	MEDIUM	2/16/1987	-29	13.9	3.8
Macomb	840,978	LOW	2/10/1912	-24	3.6	1.0
Manistee	24,733	LOW	2/11/1899	-38	4.6	1.3
Marquette	67,077	HIGH	2/17/1979	-34	35.2	9.6
Mason	28,705	LOW	2/11/1899	-38	5.6	1.5
Mecosta	42,798	MEDIUM	2/11/1899	-36	15.7	4.3
Menominee	24,029	HIGH	2/3/1996	-45	36.3	9.9
Midland	83,629	LOW	1/19/1994	-19	7.6	2.1
Missaukee	14,849	HIGH	1/30/1951	-37	24.5	6.7
Monroe	152,021	LOW	2/5/1918	-21	5	1.4
Montcalm	63,342	MEDIUM	1/19/1994	-26	11.5	3.1
Montmorency	9,765	HIGH	2/9/1934	-46	25.2	6.9
Muskegon	172,188	LOW	2/11/1899	-30	4.1	1.1
Newaygo	48,460	MEDIUM	2/1/1918	-37	13.2	3.6
Oakland	1,202,362	LOW	2/5/1918	-22	6	1.6
Oceana	26,570	LOW	2/11/1899	-35	7.3	2.0
Ogemaw	21,699	HIGH	2/10/1912	-36	23.1	6.3
Ontonagon	6,780	HIGH	2/17/1979	-42	28	7.7
Osceola	23,528	HIGH	1/15/1963	-30	24.2	6.6
Oscoda	8,640	HIGH	2/1/1918	-47	24.8	6.8
Otsego	24,164	MEDIUM	2/9/1934	-51	19.7	5.4
Ottawa	263,801	LOW	2/22/1936	-18	2.3	0.6
Presque Isle	13,376	MEDIUM	2/18/1979	-37	15.4	4.2
Roscommon	24,449	HIGH	3/3/1943	-43	20.8	5.7
Saginaw	200,169	LOW	2/5/1918	-23	7.6	2.1
Sanilac	163,040	LOW	1/23/1949	-21	8.9	2.4
Schoolcraft	61,295	HIGH	1/20/1994	-23	25.4	7.0
Shiawassee	43,114	MEDIUM	2/23/1925	-31	11.6	3.2
St. Clair	8,485	LOW	2/4/1970	-33	5.3	1.5
St. Joseph	70,648	LOW	2/5/1918	-26	8.7	2.4
Tuscola	55,729	MEDIUM	2/9/1934	-30	12.8	3.5
Van Buren	76,258	LOW	2/11/1899	-22	2.6	0.7
Washtenaw	344,791	LOW	2/5/1918	-25	5.9	1.6
Wayne	1,820,584	LOW	2/20/1929	-24	2.3	0.6
Wexford	32,735	HIGH	1/30/1951	-43	22.9	6.3
AVERAGE:				**-31.6**	**15.7**	**4.2**

Notes: *2010 Census; **Days recorded from 1971-2001.

Extreme Hot Temperatures for the State of Michigan: Risk / Probability of Occurrence

COUNTY	Population*	Relative Risk	Date of Record Hot Temperature	Record Hot Temperature °F	Number of Days Annually > 90° F**	Probability of Occurrence (%)
Alcona	10,942	LOW	8/13/1918	107	3.8	1.0
Alger	9,601	LOW	7/7/1936	103	3.1	0.8
Allegan	111,408	HIGH	7/29/1916	106	9.6	2.6
Alpena	29,598	MEDIUM	7/13/1936	106	6.2	1.7
Antrim	23,580	MEDIUM	7/13/1936	103	6.3	1.7
Arenac	15,899	MEDIUM	6/20/1995	100	6.9	1.9
Baraga	8,860	LOW	6/27/1971	96	1.6	0.4
Barry	59,173	HIGH	7/14/1936	109	10.0	2.7
Bay	107,771	MEDIUM	6/20/1995	101	8.6	2.4
Benzie	17,525	LOW	8/19/1955	95	0.9	0.2
Berrien	156,813	HIGH	6/1/1934	104	11.9	3.3
Branch	45,248	MEDIUM	7/24/1934	108	8.5	2.3
Calhoun	136,146	HIGH	7/14/1936	104	9.2	2.5
Cass	52,293	HIGH	6/20/1953	103	12.7	3.5
Charlevoix	25,949	MEDIUM	8/18/1955	102	8.9	2.4
Cheboygan	26,152	LOW	8/6/1947	104	2.7	0.7
Chippewa	38,520	LOW	8/5/1947	98	1.3	0.4
Clare	30,926	HIGH	7/13/1936	105	10.9	3.0
Clinton	75,382	HIGH	8/6/1947	102	11.3	3.1
Crawford	14,074	MEDIUM	7/11/1936	104	6.6	1.8
Delta	37,069	LOW	8/21/1955	100	0.6	0.2
Dickinson	26,168	LOW	7/13/1936	104	1.9	0.5
Eaton	107,759	MEDIUM	7/14/1936	106	7.5	2.1
Emmet	32,694	LOW	8/21/1955	99	2.0	0.5
Genesee	425,790	MEDIUM	7/8/1936	108	7.3	2.0
Gladwin	25,692	HIGH	7/13/1936	105	10.9	3.0
Gogebic	16,427	LOW	7/13/1936	103	5.7	1.6
Gd Traverse	86,986	MEDIUM	7/7/1936	105	8.8	2.4
Gratiot	42,476	HIGH	7/14/1936	108	12.0	3.3
Hillsdale	46,688	MEDIUM	7/14/1936	107	7.4	2.0
Houghton	36,628	LOW	7/7/1988	102	2.3	0.6
Huron	33,118	MEDIUM	7/8/1936	103	7.0	1.9
Ingham	280,895	HIGH	7/6/1988	100	9.1	2.5
Ionia	63,905	HIGH	7/6/1988	103	12.8	3.5
Iosco	25,887	LOW	7/8/1936	106	4.3	1.2
Iron	11,817	LOW	6/30/1963	99	4.4	1.2
Isabella	70,311	MEDIUM	8/6/1918	108	8.8	2.4
Jackson	160,248	HIGH	7/14/1936	105	10.3	2.8
Kalamazoo	250,331	HIGH	7/13/1936	109	16.3	4.5
Kalkaska	17,153	LOW	7/15/1995	96	2.3	0.6
Kent	602,622	HIGH	6/20/1953	102	9.6	2.6
Keweenaw	2,156	LOW	7/7/1988	99	1.4	0.4
Lake	11,539	MEDIUM	7/13/1936	111	7.2	2.0

Extreme Hot Temperatures for the State of Michigan: Risk / Probability of Occurrence – cont.

COUNTY	Population*	Relative Risk	Date of Record Hot Temperature	Record Hot Temperature °F	Number of Days Annually > 90° F**	Probability of Occurrence (%)
Lapeer	88,319	MEDIUM	6/26/1988	100	8.8	2.4
Leelanau	21,708	MEDIUM	7/14/1995	102	7.2	2.0
Lenawee	99,892	HIGH	7/24/1934	108	11.7	3.2
Livingston	180,967	MEDIUM	7/24/1934	104	6.3	1.7
Luce	6,631	LOW	7/13/1936	103	1.2	0.3
Mackinac	11,113	LOW	8/4/1985	93	0.1	0.0
Macomb	840,978	MEDIUM	7/5/1911	106	8.6	2.4
Manistee	24,733	LOW	8/5/1947	100	3.3	0.9
Marquette	67,077	LOW	7/19/1977	104	3.8	1.0
Mason	28,705	LOW	8/2/1988	99	3.7	1.0
Mecosta	42,798	MEDIUM	7/30/1916	103	7.6	2.1
Menominee	24,029	LOW	7/26/1955	101	5.3	1.5
Midland	83,629	HIGH	7/5/1911	107	12.6	3.4
Missaukee	14,849	LOW	7/11/1936	106	4.1	1.1
Monroe	152,021	HIGH	6/26/1988	106	19.4	5.3
Montcalm	63,342	HIGH	7/13/1936	108	11.1	3.0
Montmorency	9,765	MEDIUM	7/13/1936	104	6.4	1.8
Muskegon	172,188	LOW	7/30/1913	99	2.1	0.6
Newaygo	48,460	MEDIUM	7/13/1936	111	5.2	1.4
Oakland	1,202,362	HIGH	7/5/1911	104	10.6	2.9
Oceana	26,570	LOW	7/4/1911	104	2.9	0.8
Ogemaw	21,699	MEDIUM	7/13/1936	107	6.5	1.8
Ontonagon	6,780	LOW	7/7/1988	101	4.5	1.2
Osceola	23,528	MEDIUM	8/21/1955	100	6.5	1.8
Oscoda	8,640	MEDIUM	7/13/1936	112	7.9	2.2
Otsego	24,164	LOW	7/1/2001	101	4.6	1.3
Ottawa	263,801	LOW	6/20/1953	100	1.9	0.5
Presque Isle	13,376	LOW	7/8/1988	100	4.2	1.1
Roscommon	24,449	LOW	6/19/1995	103	3.5	1.0
Saginaw	200,169	MEDIUM	7/13/1936	111	8.9	2.4
Sanilac	163,040	MEDIUM	7/15/1977	103	7.3	2.0
Schoolcraft	61,295	LOW	7/21/1934	107	.3	0.1
Shiawassee	43,114	MEDIUM	7/24/1934	105	8	2.2
St. Clair	8,485	HIGH	7/9/1936	103	10.2	2.8
St. Joseph	70,648	HIGH	9/18/1995	120	13.7	3.7
Tuscola	55,729	HIGH	7/13/1936	108	12.4	3.4
Van Buren	76,258	HIGH	7/5/1911	105	11.2	3.1
Washtenaw	344,791	HIGH	7/24/1934	107	9.7	2.7
Wayne	1,820,584	HIGH	7/20/1930	104	11.8	3.2
Wexford	32,735	LOW	7/13/1936	104	2.9	0.8
AVERAGE:				**103.9**	**7.0**	**1.91**

Notes: *2010 Census; **Days recorded from 1971-2001.

General Natural Hazard Vulnerability: Lifelines* (utility and transportation infrastructure)

LIFELINE	Component	Primary Ownership	Flood Vulnerability	Wind Vulnerability	Earthquake Vulnerability	Winter Storm Vulnerability (snow / ice)	Extreme Temperature Vulnerability (heat / cold)	Land Subsidence Vulnerability
Oil Products Systems:	Buried Pipelines	Private	●		●			●
	Above Ground Pipelines	Private	●		●			●
	Pumping Stations	Private	●		●			●
	Well Facilities	Private			●			
	Refineries	Private	●	●	●			
	Storage Tanks	Private	●	●	●			
Natural Gas Systems:	Buried Pipelines	Private	●		●			●
	Above Ground Pipelines	Private	●		●			●
	Compressor Stations	Private			●			●
	Well Facilities	Private			●			
	Liquid Natural Gas Storage	Private	●	●	●			●
Water Systems:	Buried Pipelines	Local	●		●		●	●
	Above Ground Pipelines	Local	●		●		●	●
	Pumping Stations	Local	●		●	●	●	●
	Treatment Plants	Local	●	●	●	●	●	●
	Storage Tanks	Local	●	●	●	●	●	●
Wastewater Systems:	Buried Pipelines	Local	●		●		●	●
	Above Ground Pipelines	Local	●		●		●	●
	Pumping Stations	Local	●		●	●	●	●
	Treatment Plants	Local	●	●	●	●	●	●
	Storage Basins	Local	●	●	●	●	●	●
Storm Drainage:	Buried Pipelines	Local	●		●		●	●
	Open Channels	Local	●		●	●	●	●
	Catch Basins / Outflows	Local	●		●	●		●
	Storage Basins	Private / Local	●		●	●	●	●
Electric Power Systems:	Substations	Private / Local	●	●	●	●		●
	Transmission Towers / Poles	Private / Local	●	●	●	●		●
	Distribution Poles	Private / Local	●	●	●	●		●
	Buried Cables	Private / Local	●	●	●	●		●

General Natural Hazard Vulnerability: Lifelines* (utility and transportation infrastructure) – cont.

LIFELINE	Component	Primary Ownership	Flood Vulnerability	Wind Vulnerability	Earthquake Vulnerability	Winter Storm Vulnerability (snow / ice)	Extreme Temperature Vulnerability (heat / cold)	Land Subsidence Vulnerability
Telecommunications:	Towers / Masts / Poles	Private	●	●	●	●		●
	Buried Cables	Private	●		●			●
	Underwater Cables	Private			●			
	Above Ground Cables	Private	●	●	●	●		●
	Switching Equipment	Private	●	●	●	●		●
Highways and Roads:	Bridges	Local / State	●		●	●		
	Embankments	Local / State	●		●	●		●
	Road Beds	Local / State	●		●	●	●	●
	Culverts	Local / State	●		●	●		●
	Tunnels	Local / State	●		●			●
	Signs / Signals	Local / State	●	●	●	●	●	●
Ports / Inland Waterways:	Breakwaters / Jetties	Local / State	●	●				
	Sea Walls	Local / State	●	●	●	●		
	Container Handling	Private	●	●		●		
	Cargo Movement Facilities	Private	●	●		●		
	Marine Oil Terminals	Private	●	●	●	●		
Railroads:	Bridges	Private	●		●	●		●
	Embankments	Private	●		●	●		●
	Rails / Ties / Ballast	Private	●		●	●	●	●
	Culverts	Private	●		●	●		●
	Signs / Signals	Private	●	●	●	●	●	●
Airports:	Terminal Buildings	Local	●	●	●	●		●
	Aircraft Hangars	Local / Private	●	●	●	●		●
	Runways / Taxiways	Local	●		●	●	●	●
	Lights / Signs / Signals	Local	●	●	●	●	●	●
	Access Roads / Parking Areas	Local	●		●	●	●	●

Notes: *Based on the American Lifelines Alliance 2003 and Michigan disaster events.

Loss Estimation Tables for State Critical Facilities

NOTE: Actual information about facility names, addresses, etc. are withheld from public versions of this document. They are only available for access to authorized persons.

INTRODUCTORY TEXT SECTIONS:
General Loss Estimation for Natural Hazards
Methods for Broadly Analyzing Impacts of Specific Natural Hazards
State Owned/Operated Critical Facility Loss Estimation for Location Specific Natural Hazards
State Owned/Operated Critical Facility Loss Estimation for Non-Location Specific Natural Hazards

LOSS ESTIMATION AND RELATED TABLES:
1. General Hazard Vulnerability of State Owned/Operated Critical Facilities Addressed in this Plan
2. State Owned/Operated Critical Facilities – Wildfires
3. State Owned/Operated Critical Facilities – Flooding
4. State Owned/Operated Critical Facilities – Land Subsidence
5. State Owned/Operated Critical Facilities – Earthquake
6. State Owned/Operated Critical Facilities – Dam Failure Area
7. General Natural Hazard Vulnerability: Lifelines (utility and transportation infrastructure)

State Owned/Operated Critical Facility Loss Estimation for Significant Natural Hazards

GENERAL METHODOLOGY

In late 2013, the Michigan Department of Technology, Management, and Budget had provided its latest list of state facilities for analysis in this plan. These included state owned facilities as well as leased facilities, thus constituting the best available list of state owned/operated facilities and infrastructure. This list was analyzed in its entirety during early 2014, using the following procedure. There were 538 facilities (26 more than had been analyzed in the previous plan), although 6 of these were located outside fo the state. The value of each facility was already provided by MDTMB for the list of state-owned facilities, but needed to be estimated for the list of state-leased facilities. Square-footage information was available for the list of state-leased facilities, and information about the type of facility use was available for the entire list. Using this information, along with the online RSMeans calculator which provided a per-square-foot value for each property type, the total values of each state-leased facility were calculated.

The available list of RSMeans building types had to be matched up with the closest corresponding state facilities use classifications. The following table shows what RSMeans categories were selected to represent the state facility use classifications:

State Facility Use Classification	Selected RSMeans Building Type Classification
Hospital	Hospital, 2-3 story
Laboratory	College laboratory
Mechanic Shop	Garage, repair
Mixed Use	Store, Department, 2-story
Office Building	Office, 2-4 story
Retail	Store, retail
Training	College, classroom
Warehouse	Warehouse
(Parking, Other)	(No structures; not assessed)

The categories were selected so that the averages for each facility type would represent the average characteristics of each classification type, between the two sources. For most facilities, state facility building data was plugged directly into the RSMeans tool to produce individual results. For the office building classification (the majority of state facilities), an average of $359 per square foot was used—a calculated representation of the central tendency in the RSMeans data, after testing several cases at both extremes of the floor area range across state facilities, so that variation in the square footage of structures at both ends of the range would approximately balance out across the hundreds of office facilities. The RSMeans results are based on 3rd quarter 2012 national average costs for that type of construction (not location-specific results). The values assume union wage labor and construction with no basements. RSMeans offers three estimation ranges— low, medium, and high, and the values chosen were always the medium result (including architectural fees, contractor overhead, and contractor profit). The result was considered to be an appropriate estimate of the replacement costs of current facilities.

Next, the list of facilities (in a spreadsheet) was sorted by location according to county. Although not included in public versions of this document, the facilities list includes lat/long, address, city, and county location information, which state department controls the facility, a classification and/or description of each facility's use, its square footage, and its total value. Added to this spreadsheet were columns representing the results of the county loss assessments in this Attachment and the main hazard analysis sections of this document. Cells of the spreadsheet were populated with formulas that took the annual expected damages from each significant natural hazard, in each county, and divided it by the total assessed property values within that county, to produce a ratio that represents the expected damages per unit-value of assessed property. The county property assessment information was obtained from http://www.michigan.gov/treasury/0,1607,7-121-1751_2228_21957_45818---,00.html, a Michigan Department of Treasury web site. In order to best match the kind of damage information reported in the NCDC records, all types of property (including building contents) were included in the collected assessment data. A ratio of the county's average annual damages by hazard, compared with the total assessed property value in that county, resulted in a value for each county that represented the average damage from each hazard per property valuation. This provided the necessarily link to estimate the expected losses to each state facility in

Michigan's numerous counties. The derived ratio, which was in effect an average percentage of property values in each county that is annually lost to each hazard, was applied as a factor to the full list of state facility property values, resulting in multiple columns that provide estimated annual losses to each facility, by hazard type. Note that the described factor does vary throughout the state, according to each facility's county of location. The results were considered far more sophisticated and valid than those obtained from methods used in any of the previous editions of this plan. By totaling all hazards for each facility, a combined estimate of damages from all significant natural hazards was also produced, and in addition, by totaling the columns for each hazard and all hazards' impacts within the spreadsheet, total expected annual losses for all state facilities, by hazard as well as in total, were also produced. (As explained under the county loss assessments, and for the same reasons, assessments were not made for Michigan's least-damaging natural hazards [as listed previously], because of a dearth of validly generalizable data and too-short of an historical time frame over which analytically usable data is currently available.)

GENERAL FINDINGS

The results of the loss estimation procedure for all facilities are presented in the following list:

1. State facility annual expected losses from flooding: $200,363
2. State facility annual expected losses from severe winds $114,793
3. State facility annual expected losses from tornadoes $106,577
4. State facility annual expected losses from hail $ 99,032
5. State facility annual expected losses from ice/sleet storms $ 43,915
6. State facility annual expected losses from snowstorms $ 8,401
7. State facility annual expected losses from wildfire $ 7,406
8. State facility annual expected losses from lightning $ 4,427

Total state facility annual expected losses from all significant natural hazards: $584,912. On their face, these values all seem quite realistic, although the flood hazard needed to be assessed in an additional manner, since the raw application of county-wide trends to a limited number of specific sites was considered less accurate for that hazard than the application of county-wide trends to the general weather hazards. The most significant hazards in each county, and the most at-risk counties for each hazard (as described previously) parallel the loss estimates for state facilities and infrastructure located in each county (or multi-county risk regions) in the state. But with flooding, there are specific floodplain locations identified, and these were able to be compared with state facility locations, using Geographic Information Systems, for the approximately one-half of the Michigan Counties for which digital Flood Insurance Rate Maps (dFIRMs) were available. (See the maps in the riverine flood section of the main body of this plan, for more details.) The resulting geographic analysis identified 11 state facilities that appeared to have some level of flood risk. Although only two facilities fell squarely within the floodplains, it was considered a bit more realistic to assess flood risks by slightly expanding the analytic routine to include an additional 200-foot search radius. (Topographic analysis was not a readily available mechanism to use for this procedure, although it should be considered as an additional factor in subsequent analyses for future editions of this plan. Given that dFIRM data was not yet available for the entire state, a more complex analysis of available data might have led to "false precision" when it comes to the full assessment of all facilities. In this sense, the $200,363 figure provided above might indeed be more reflective in certain ways of actual flood risks, since it is based upon as assessment of all counties in Michigan.)

As briefly described in the text box on page 641, this second method of flood analysis made use of information from a FEMA flood damage estimation table, using the category of less than ½ foot of surface flooding (2 or more feet in any basement) and the 2 story no basement category, to better translate the resilience of state facilities from the original weaker structures the FEMA table had been produced to represent (i.e. the inclusion and comparison of various residential structures, including mobile homes; whereas the durability of state facilities would be expected on average to be greater than such residences). The result was to use an estimated damage amount of 5% of replacement value per flood event. Because of the more significant value of structure contents in state facilities, however, than the FEMA residential baseline provided in the table, the estimated total losses were doubled, to 10% of the structure's replacement value. The probability of flooding was represented as 1% chance per year, following the typical definition of a floodplain. The result was to find that the 11 structures, which had a total value of $114,251,137, would have annual expected losses of $114,251 from the flood hazard. There may be additional facilities in the floodplains outside of those areas for which dFIRMs were available, however it does appear that both methods of analysis are corresponding with each other, and the estimated $200,000 annual loss estimate from flooding (found above) is likely to be accurate, after all.

NOTE: Publicly available versions of this document do not include pages 687-706, in order to preserve the confidentiality of certain information regarding Michigan's critical facilities so that it is not misused. This information may be examined by authorized personnel only.